FINAL
ENVIRONMENTAL IMPACT STATEMENT
MARCH 1995

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13. ABSTRACT *(Maximum 200 words)*

Pursuant to the DOD Appropriations Act for Fiscal Year 1991 (Public Law 101-511), the Air Force selected the Univ of PA, Phila PA, as the recipient of a grant to support the initial construction of an Institute of Advanced Science and Technology (IAST). This FEIS has been prepared in accordance with the National Environmental Policy Act (NEPA) of 1969 to analyze the potential environmental consequences of the siting, construction, and operation of the IAST. Although grant distribution would have few, if any, direct effects, future actions would create direct effects. This document, therefore, includes anaylses of the potential impacts that a range of reasonable may have on the local community, including land use and aesthetics, transportation, utilities, hazardous materials/wastes, geology and soils, water resources, air quality, noise, biological resources, and cultural and archaeological resources. The alternatives include two configurations of the IAST at the Smith Hall site, one of which is the Proposed Action, and two siting alternatives at other campus locations. The impact of the No-action alternatives were also considered. The potential impacts associated with the alternatives would be similar to those for the proposed action.

14. SUBJECT TERMS

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APPENDIX A

APPENDIX A

GLOSSARY OF TERMS, ACRONYMS, AND ABBREVIATIONS

GLOSSARY OF TERMS

A-Weighted Sound Level (dBA). A number representing the sound level, which is frequency weighted according to a prescribed frequency response established by the American National Standards Institute (ANSI S1.4-1972) and accounts for the response of the human ear.

Acoustics. The science of sound which includes the generation, transmission, and effects of sound waves, both audible and inaudible.

Advisory Council on Historic Preservation. A 19-member body appointed, in part, by the President of the United States to advise the President and Congress and to coordinate the actions of federal agencies on matters relating to historic preservation, to comment on the effects of such actions on historic and archaeological cultural resources, and to perform other duties as required by law (Public Law 89-655; 16 USC 470).

Aesthetics. Refers to an environment's visual character and quality.

Aggregate. Materials such as sand, gravel, or crushed stone used for mixing with a cementing material to form concrete or alone as railroad ballast or graded fill.

Ambient Air Quality Standards. Standards established on a state or federal level that define the limits for airborne concentrations of designated "criteria" pollutants (nitrogen dioxide, sulfur dioxide, carbon monoxide, total suspended particulates, ozone, and lead), to protect public health with an adequate margin of safety (primary standards) and to protect public welfare, including plant and animal life, visibility, and materials (secondary standards).

Aquifer. The water-bearing portion of subsurface earth material that yields or is capable of yielding useful quantities of water to wells.

Archaeology. A scientific approach to the study of human ecology, cultural history, and cultural process.

Arterial. A signalized street that serves primarily through-traffic and provides access to abutting properties as a secondary function.

Asbestos. A carcinogenic substance formerly used widely as an insulation material by the construction industry; often found in older buildings.

Attainment Area. A region that meets the National Ambient Air Quality Standards for a criteria pollutant under the Clean Air Act.

Average Daily Traffic (ADT). For a 24-hour period, the total volume passing a point or segment of a highway facility in both directions, divided by the number of hours in the day.

Average Travel Speed. The average speed of a traffic stream computed as the length of a highway segment divided by the average travel times of vehicles traversing the segment, in miles per hour.

Bioengineering. The application of engineering principles or design to biological systems, e.g., prosthetics development.

Biologically Active Molecules. Molecules that have a function in biological systems, e.g., proteins, enzymes, ribonucleic acid.

Biophysical. Pertaining to the physical and biological environment, including the environmental conditions crafted by man.

Biota. The plant and animal life of a region.

Biotechnology. The application of biological and engineering principles to problems relating to humans and machine.

Capacity. The maximum rate of flow at which vehicles can be reasonably expected to traverse a point on a uniform segment of a lane or roadway during a specified time period under prevailing roadway, traffic, and control conditions.

Carbon Monoxide (CO). A colorless, odorless, poisonous gas produced by incomplete fossil-fuel combustion. One of the six pollutants for which there is a national ambient standard. See Criteria Pollutants.

Chemical Hygiene Plan (CHP). The University's manual that provides basic safety information on the use of chemicals in the laboratory.

Comprehensive Plan. A public document, usually consisting of maps, text, and supporting materials, adopted and approved by a local government legislative body, which describes future land uses, goals, and policies.

Contaminants. Undesirable substances rendering something unfit for use.

Council on Environmental Quality (CEQ). Established by the National Environmental Policy Act (NEPA), the CEQ consists of three members appointed by the President. CEQ regulations (40 CFR Parts 1500-1508, as of July 1, 1986) describes the process for implementing NEPA, including preparation of environmental assessments and environmental impact statements, and the timing and extent of public participation.

Corrosive. A material that has the ability to cause visible destruction of living tissue and has a destructive effect on other substances. An acid or a base.

Criteria Pollutants. The Clean Air Act required the Environmental Protection Agency to set air quality standards for common and widespread pollutants after preparing "criteria documents" summarizing scientific knowledge on their health effects. Today there are standards in effect for six "criteria pollutants": sulfur oxide (SO_2), carbon monoxide (CO), particulate matter less than 10 microns in diameter (PM_{10}), nitrogen dioxide (NO_2), ozone (O_3), and lead (Pb).

Cultural Resources. Prehistoric and historic districts, sites, buildings, objects, or any other physical evidence of human activity considered important to a culture, subculture, or a community for scientific, traditional, religious, or any other reason.

Cumulative Impacts. The impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. (40 CFR 1508.7)

Curie. A unit of radioactivity equal to 3.7E10 disintegrations per second.

Day-Night Average Sound Level (DNL). The 24-hour average-energy sound level expressed in decibels, with a 10-decibel penalty added to sound levels between 10:00 p.m. and 7:00 a.m. to account for increased annoyance due to noise during night hours.

Decibel (dB). A unit of measurement on a logarithmic scale which describes the magnitude of a particular quantity of sound pressure or power with respect to a standard reference value.

Dry Lab. A laboratory space equipped with electronics for research not utilizing wet chemistry, primarily computer research (hardware, software).

Easement. A right or privilege (agreement) that a person may have on another's property.

Effluent. Waste material discharged into the environment.

Endangered Species. A species that is threatened with extinction throughout all or a significant portion of its range.

Environmental Impact Analysis Process. The process of conducting environmental studies as outlined in Air Force Regulation 19-2.

Environmental Protection Agency (EPA). The independent federal agency, established in 1970, that regulates environmental matters and oversees the implementation of environmental laws.

Erosion. Wearing away of soil and rock by weathering and the action of streams, wind, and underground water.

Freeway. A multilane divided highway having a minimum of two lanes for exclusive use of traffic in each direction and full control of access and egress.

Frequency. The time rate (number of times per second) that the wave of sound repeats itself, or that a vibrating object repeats itself — now expressed in Hertz (Hz), formerly in cycles per second (cps).

Friable. Easily crumbled or reduced to powder.

Functional Hierarchy of Roadways. Classification of roadways by the relative importance of the movement and access function assigned to them.

Gene Therapy. The addition or replacement of mutant or defective genes with beneficial genes.

Habituate. To become accustomed to frequent repetition or prolonged exposure.

Hazardous Material. Substances defined as hazardous by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 U.S. Code (U.S.C.) 9601-9675, as amended, and the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6901-6992, as amended. In general, substances are classified as hazardous if their quantity, concentration, or physical, chemical, or infectious characteristics may present substantial danger to public health or welfare or the environment when released into the environment. Many substances frequently encountered in daily life are considered hazardous when released into the environment in sufficient quantity, such as house paint, automobile batteries, and laundry bleach. However, when disposed of properly these materials are not considered hazardous.

Hydrocarbons (HC). Any of a vast family of compounds containing hydrogen and carbon. Used loosely to include many organic compounds in various combinations; most fossil fuels are composed predominately of hydrocarbons. When hydrocarbons mix with nitrogen oxides in the presence of sunlight, ozone is formed; hydrocarbons in the atmosphere contribute to the formation of ozone.

Impacts. An assessment of the meaning of changes in all attributes being studied for a given resource; an aggregation of all the adverse effects, usually measured using a qualitative and nominally subjective technique. In this EIS, as well as in the CEQ regulations, the word impact is used synonymously with the word effect.

Infill. A building addition situated between and closely interconnected with existing structures.

Infrastructure. The basic installation and facilities on which the continuance and growth of a community, state, etc., depend, e.g., roads, schools, power plants, transportation, and communication systems.

Interstate. The designated National System of Interstate and Defense Highways located in both rural and urban areas; they connect the East and West coasts and extend from points on the Canadian border to various points on the Mexican border.

L_{eq}. The equivalent steady sound level which in a stated period of time would contain the same acoustical energy as the time-varying sound level during the same period.

L_{max}. The highest A-weighted sound level observed during a single event of any duration.

Laboratory Scale. Work with substances in which the containers used for the reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person.

Lead (Pb). A heavy metal used in many industries, which can accumulate in the body and cause a variety of negative effects. One of the six pollutants for which there is a national ambient air quality standard. See Criteria Pollutants.

Level of Service (LOS). In transportation analyses, a qualitative measure describing operational conditions within a traffic stream and how they are perceived by motorists and/or passengers. In enforcement services available to community residents, generally expressed as the number of personnel providing the services per 1,000 population.

Loudness. The qualitative judgement of intensity of a sound by a human being.

Masking. The action of bringing one sound (audible when heard alone) to inaudibility or to unintelligibility by the introduction of another sound.

Mineral. Naturally occurring inorganic element or compound.

Mineral Resources. Mineral deposits that may eventually become available; known deposits not recoverable at present or yet undiscovered.

Mitigation. A method or action to reduce or eliminate program impacts.

Modal Split. The division of travel between transit and automobiles.

Multiple Family Housing. Townhouse or apartment units that accommodate more than one family though each dwelling unit is only occupied by one household.

National Ambient Air Quality Standards (NAAQS). Section 109 of the Clean Air Act requires EPA to set nationwide standards, the National Ambient Air Quality Standards, for widespread air pollutants. Currently, six pollutants are regulated by primary and secondary NAAQS: carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter (PM_{10}), and sulfur dioxide. See Criteria Pollutants.

National Priorities List. A list of sites (federal and state) that contain hazardous materials that may cause an unreasonable risk to the health and safety of individuals, property, or the environment.

National Register of Historic Places. A register of districts, sites, buildings, structures, and objects important in American history, architecture, archaeology, and culture, maintained by the Secretary of the Interior under authority of Section 2(b) of the Historic Sites Act of 1935 and Section 101(a)(1) of the National Historic Preservation Act of 1966, as amended.

Native Americans. Used in a collective sense to refer to individuals, bands, or tribes who trace their ancestry to indigenous populations of North America prior to Euro-American contact.

Native Vegetation. Plant life that occurs naturally in an area without agricultural or cultivational efforts. It does not include species that have been introduced from other geographical areas and become naturalized.

National Environmental Policy Act (NEPA). Public Law 91-190 (42 USC 4321), passed by Congress in 1969. The Act established a national policy designed to encourage consideration of the influences of human activities (e.g., population growth, high-density urbanization, industrial development) on the natural environment. NEPA also established the Council on Environmental Quality. NEPA procedures require that environmental information be made available to the public before decisions are made. Information contained in NEPA documents must focus on the relevant issues in order to facilitate the decisionmaking process.

Nitrogen Dioxide (NO_2). Gas formed primarily from atmospheric nitrogen and oxygen when combustion takes place at high temperature. NO_2 emissions contribute to acid deposition and formation of atmosphere ozone. One of the six pollutants for which there is a national ambient standard. See Criteria Pollutants.

Nitrogen oxides (NO_X). Gases formed primarily by fuel combustion, which contribute to the formation of acid rain. Hydrocarbons and nitrogen oxides combine in the presence of sunlight to form ozone, a major constituent of smog.

Noise. Any sound that is undesirable because it interferes with speech and hearing, or is intense enough to damage hearing, or is otherwise annoying (unwanted sound).

Noise Attenuation. The reduction of a noise level from a source by such means as distance, ground effects, or shielding.

Noise Contour. A curve connecting points of equal noise exposure on a map. Noise exposure is often expressed using the average day-night sound level, DNL.

Nonattainment Area. An area that has been designated by the Environmental Protection Agency or the appropriate state air quality agency, as exceeding one or more National or State Ambient Air Quality Standards.

100-Year Flood Zone. Land area having a 1-percent chance of being flooded during a given year.

Ozone (ground level). A major ingredient of smog. Ozone is produced from reactions of hydrocarbons and nitrogen oxides in the presence of sunlight and heat. Some 68 areas, mostly metropolitan areas, did not meet a 31 December 1987 deadline in the Clean Air Act for attaining the ambient air quality standard for ozone.

Passenger Car Equivalent. The number of passenger cars that are displaced by a single heavy vehicle of a particular type under prevailing roadway, traffic, and control conditions.

Permeability. The capacity of a porous rock or sediment to transmit a fluid.

Potable Water. Suitable for drinking.

Prehistoric. The period of time before the written record.

Prevention of Significant Deterioration (PSD). In the 1977 Amendments to the Clean Air Act, Congress mandated that areas with air cleaner than required by national ambient air quality standards must be protected from significant deterioration. The Clean Air Act's PSD program consists of two elements: requirements for best available control technology on major new or modified sources and compliance with an air quality increment system.

Prevention of Significant Deterioration Area. A requirement of the Clean Air Act (160 et seq.) that limits the increases in ambient air pollutant concentrations in clean air areas to certain increments even though ambient air quality standards are met.

Prime Farmland. Environmentally significant agricultural lands protected from irreversible conversion to other uses.

Primary Roads. A consolidated system of connected main roads important to regional, statewide, and interstate travel; they consist of rural arterial routes and their extensions into and through urban areas of 5,000 or more population.

Radioisotopes. Radioactive species of an element with the same atomic number but with different atomic mass.

Radionuclides. Radioactive species of an atom characterized by the constitution of its nucleus, i.e., the number of protons and neutrons.

Recent. The time period from approximately 10,000 years ago to the present and the rocks and sediments deposited during that time.

Ruderal. Weedy or introduced vegetation growing in disturbed areas.

Sediment. Material deposited by wind or water.

Sharps. All hypodermic needles and syringes, suture needles, disposable razors, pasteur pipettes, scalpel blades, and broken glass that has been in contact with pathogenic organisms. (University of Pennsylvania Biological Safety Manual, 1991, p.2).

Short Ton. 2,000 pounds.

Shrink/Swell Potential. Volume change possible upon wetting or drying.

Single-Family Housing. A conventionally built house consisting of a single dwelling unit occupied by one household.

Site. As it relates to cultural/resources, any location where humans have altered the terrain or discarded artifacts.

Solvent. A substance that dissolves or can dissolve another substance.

Sound. The auditory sensation evoked by the compression and rarefaction of the air or other transmitting medium.

Specific Plan. A plan regulating development within a defined area of a city, consistent with the city's General Plan. Specific plans are required prior to development in specified areas that have not been zoned for particular land uses.

State Historic Preservation Officer. The official within each state, authorized by the State at the request of the Secretary of the Interior, to act as liaison for purposes of implementing the National Historic Preservation Act.

Sulfur Dioxide (SO_2). A toxic gas that is produced when fossil fuels, such as coal and oil, are burned. SO_2 is the main pollutant involved in the formation of acid rain. SO_2 also can irritate the upper respiratory tract and cause lung damage. During 1980, some 27 million tons of sulfur dioxide were emitted in the U.S., according to the Office of Technology Assessment. The major source of SO_2 in the U.S. is coal-burning electric utilities.

Tectonic Framework. Structural elements of a region including the rising, stable, and subsiding areas.

Therm. A measurement of units of heat.

Threatened Species. Plant and wildlife species likely to become endangered in the foreseeable future.

Traffic Assignment. The allocation of traffic flows among routes available between any two places.

Transgenic Research. Research involving the movement of genetic material from one organism to another.

Transportation Demand Management (TDM). Short-range programs that deal with traffic operations, ridesharing, transit and high-occupancy vehicles, appropriate provisions for pedestrians and bicycles, parking control, flex-time, staggered work hours and others.

Trip Distribution. A determination of the interchange of trips among zones in a region.

Trip Generation. A determination of the quantity of trip ends associated with a parcel of land.

Wetlands. Areas that are inundated or saturated with surface or groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil. This classification includes swamps, marshes, bogs, and similar areas.

Vehicle Trip End. A one-direction vehicle movement with either the origin and/or destination or both inside the study site.

Volume. The number of vehicles passing a point on a lane, roadway, or other trafficway during some time interval.

Wet lab. A laboratory space fully equipped with plumbing, fume hoods, and associated equipment as required for wet chemical research and designed to protect the researcher and the environment.

Zoning. The division of a municipality (or county) into districts for the purposes of regulating land use, types of building, required yards, necessary off-street parking, and other prerequisites to development. Zones are generally shown on a map and the text of the zoning ordinance specifies requirements for each zoning category.

ACRONYMS AND ABBREVIATIONS

ACM	Asbestos-containing material
ADT	average daily traffic
AFOSR	Air Force Office of Scientific Research
ANSI	American National Standards Institute
Be	beryllium
BFI	Browning Ferris Industries
CAA	Clean Air Act
CEB	Center for Bioengineering
CECCE	Chemistry and Chemical Engineering
CECICS	Center for Computer, Information, and Cognitive Science
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CHOP	Children's Hospital of Philadelphia
CHP	Chemical Hygiene Plan
CO	carbon monoxide
CSTIR	Center for Scientific and Technological Information Resources
CTT	Center for Technology Transfer
DEIS	Draft Environmental Impact Statement
DOD	Department of Defense
DRL	David Rittenhouse Laboratory
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FEIS	final EIS
GDCW	Guidelines for the Disposal of Chemical Wastes
GSF	Gross Square Feet
HABS	Historic American Building Standards
HICNOM	Highway Construction Noise Computer Program
HVAC	industrial noise
IAST	Institute for Advanced Science and Technology
LAAQS	Local Ambient Air Quality Standards
LAER	lowest achievable emission rates
LRSM	Laboratory for Research on the Structure of Matter
MACT	maximum achievable control technology
MOA	Memorandum of Agreement
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NMR	nuclear magnetic resonance
NO_2	nitrogen dioxide
NOI	Notice of Intent
NO_x	oxides
NRC	U.S. Nuclear Regulatory Commission
NRHD	National Register Historic District
NSF	Net Square Feet
O_3	ozone

OEHS	Office of Environmental Health and Safety
OSHA	Occupational Safety and Health Administration
PADER	Pennsylvania Department of Environmental Resources
Pb	lead
PCBs	polychlorinated biphenyls
PM_{10}	particulate matter of less than 10 micrometer diameter
PMSA	Philadelphia Primary Metropolitan Statistical Area
PPC	Preparedness, Prevention and Contingency
RCRA	Resource Conservation and Recovery Act
RFP	Request for Proposals
ROD	Record of Decision
ROG	reactive organic gases
ROI	Region of Influence
SAS	School of Arts and Sciences
SEAS	School of Engineering and Applied Science
SHPO	State Historic Preservation Office
SIP	State Implementation Plan
SO_2	sulfur dioxide
TSP	total suspended particulates
USC	U.S. Code
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compounds

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APPENDIX B

APPENDIX B

NOTICE OF INTENT
NOTICE EXTENDING THE SCOPING PERIOD

The following Notice of Intent was circulated and published by the Air Force in the July 31, 1992, Federal Register in order to provide public notice of the Air Force's intent to prepare an Environmental Impact Statement for the Institute for Advanced Science and Technology.

Department of the Air Force

Notice of Intent To Prepare an Environmental Impact Statement for the Institute of Advanced Science and Technology at the University of Pennsylvania, Philadelphia, PA

The United States Air Force will prepare an Environmental Impact Statement (EIS) to assess the potential environmental impacts of the construction of the Institute of Advanced Science and Technology (IAST) to be located at the University of Pennsylvania, Philadelphia, Pennsylvania.

In Fiscal Year 1991, Congress provided a ten million dollar grant to establish IAST. The grant was awarded to the University of Pennsylvania through competitive procedures. The

Cognitive Science, Chemistry and Chemical Engineering, and Bioengineering, in addition to training future scientists and engineers. It would also facilitate the transfer of research findings to practical applications. The proposal calls for the demolition of an existing campus structure designated as an historic property, the construction of 100,000 square feet of new laboratory space, and the adaptive reuse of adjacent University buildings for related purposes.

The Air Force will conduct a scoping meeting to obtain public input to assist in determining the nature, extent and scope of environmental issues and concerns to be addressed in the EIS. The scoping meeting will be held at the University of Pennsylvania on August 19, 1992 in the Wistar Auditorium, 3601 Spruce Street, Philadelphia, Pennsylvania.

Public input and comments are solicited concerning the environmental impacts of the proposed program. If concerned persons are not able to attend the scoping meeting, written comments and suggestions will be accepted. To ensure that the Air Force will have sufficient time to fully consider public inputs on issues to be included in the EIS, written comments should be forwarded to the address below by September 11, 1992. Interested persons who seek further information concerning the IAST project or wish to comment on the proposed action and EIS should contact: Lt. Col. Gary P. Baumgartel, AFCEE/ESE, Building 1155, Brooks AFB, Texas 78235-5000, (512) 536-3869.

Patsy J. Conner,

Air Force Federal Register Liaison Officer.

[FR Doc. 92-17320 Filed 7-30-92; 8:45 am]

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DEPARTMENT OF DEFENSE

Department of the Air Force

Extension of the Scoping Comment Period for the Environmental Impact Statement for the Institute of Advanced Science and Technology at the University of Pennsylvania, Philadelphia, PA

The United Stares Air Force has extended the scoping comment period for the Environmental Impact Statement (EIS) on the University of Pennsylvania Institute for Advanced Science and Technology (IAST). The scoping comment period has been extended from September 11, 1992 to October 1, 1992 in order to provide additional opportunity for the public to provide input on issues to be considered in the EIS.

The IAST is a proposed program to construct new facilities at the University of Pennsylvania, Philadelphia, Pennsylvania.

Interested persons who seek further information concerning the IAST project or wish to provide comments on issues to be considered for inclusion in the EIS should contact: Lt Col Gary P. Baumgartel, AFCEE/ESE, Building 1155, Brooks AFB, Texas 78235–5000, (512) 536–3869.

Patsy J. Conner,

Air Force Federal Register Liaison Officer.

[FR Doc. 92–21630 Filed 9–8–92; 8:45 am]

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APPENDIX C

IAST-EIS MAILING LIST

CONGRESSIONAL

The Honorable Arlen Specter
United States Senate

The Honorable Richard Santorum
United States Senate

The Honorable Thomas Foglietta
House of Representatives

The Honorable Chaka Fattah
House of Representatives

The Honorable Robert Borski
House of Representatives

The Honorable Daniel K. Inouye
United States Senate

The Honorable Ronald V. Dellums
House of Representatives

The Honorable Joseph N. McDade
House of Representatives

The Honorable John P. Murtha
House of Representatives

The Honorable Curt Weldon
House of Representatives

The Honorable James Greenwood
House of Representatives

The Honorable Jon Fox
House of Representatives

The Honorable Robert S. Walker
House of Representatives

STATE OF PENNSYLVANIA

The Honorable Thomas Ridge
Office of the Governor

The Honorable David J. Brightbill
Chairman
Senate Environ. Res. & Energy Committee

The Honorable Eugene Posterfield
Minority Chairman
Senate Environ. Res. & Energy Comm.

The Hon. Camille George., Chairman
House Conservation Committee

The Honorable Robert Rosen
Minority Chairman
House Conservation Committee

The Honorable Harold James
House of Representatives

The Honorable Vincent Hughes
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The Honorable Hardy Williams
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William C. Bostic, Secretary
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IAST-EIS MAILING LIST

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The Honorable Allyson Schwartz
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The Honorable John M. Peszik
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The Honorable Dwight Evans
State House of Representatives

The Honorable James R. Roebuck
State House of Representatives

The Honorable Mike Horsey
State House of Representatives

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IAST-EIS MAILING LIST

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Eugene Clekley, Chief
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U.S. Department of Transportation

William McGovern, Environ. & Planning
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Anthony E. Costa, Chief
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LTC Robert Magnifico
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Robert Gift
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Eric Feldman, Area Administrator
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Public Health Service History Office

IAST-EIS MAILING LIST

CITY OF PHILADELPHIA

The Hon. Edward G. Rendell, Mayor
City of Philadelphia

Bennett Levin, Commissioner
Department of Licenses and Inspections

Michael DiBerardinis, Commissioner
Department of Recreation

Joan Reeves, Commissioner
Department of Human Services

V. Chapman-Smith, Commissioner
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The Honorable Anna Cibotti Verna
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The Honorable Michael A. Nutter
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Councilwoman

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APPENDIX D

D1
TRAFFIC IMPACT ANALYSIS

D1.1 INTRODUCTION

Traffic Planning and Design, Inc. examined the impact of the proposed building on the surrounding roadway network. Of the several sites originally considered the following three sites, indicated in Figure D1.1-1, are currently under consideration for locating the proposed building, and thus the subject of these more detailed investigations:

1. The Proposed Action and Reuse of a Portion of Smith Hall sites at the existing Smith Hall on 34th Street, adjacent to the Chemistry Building.
2. The LRSM parking lot site at the existing parking lot on the north side of Walnut Street, east of the LRSM building.
3. The Lott Tennis Courts site on 33rd Street, north of Franklin Field.

The impact at each proposed location will be analyzed for two conditions:

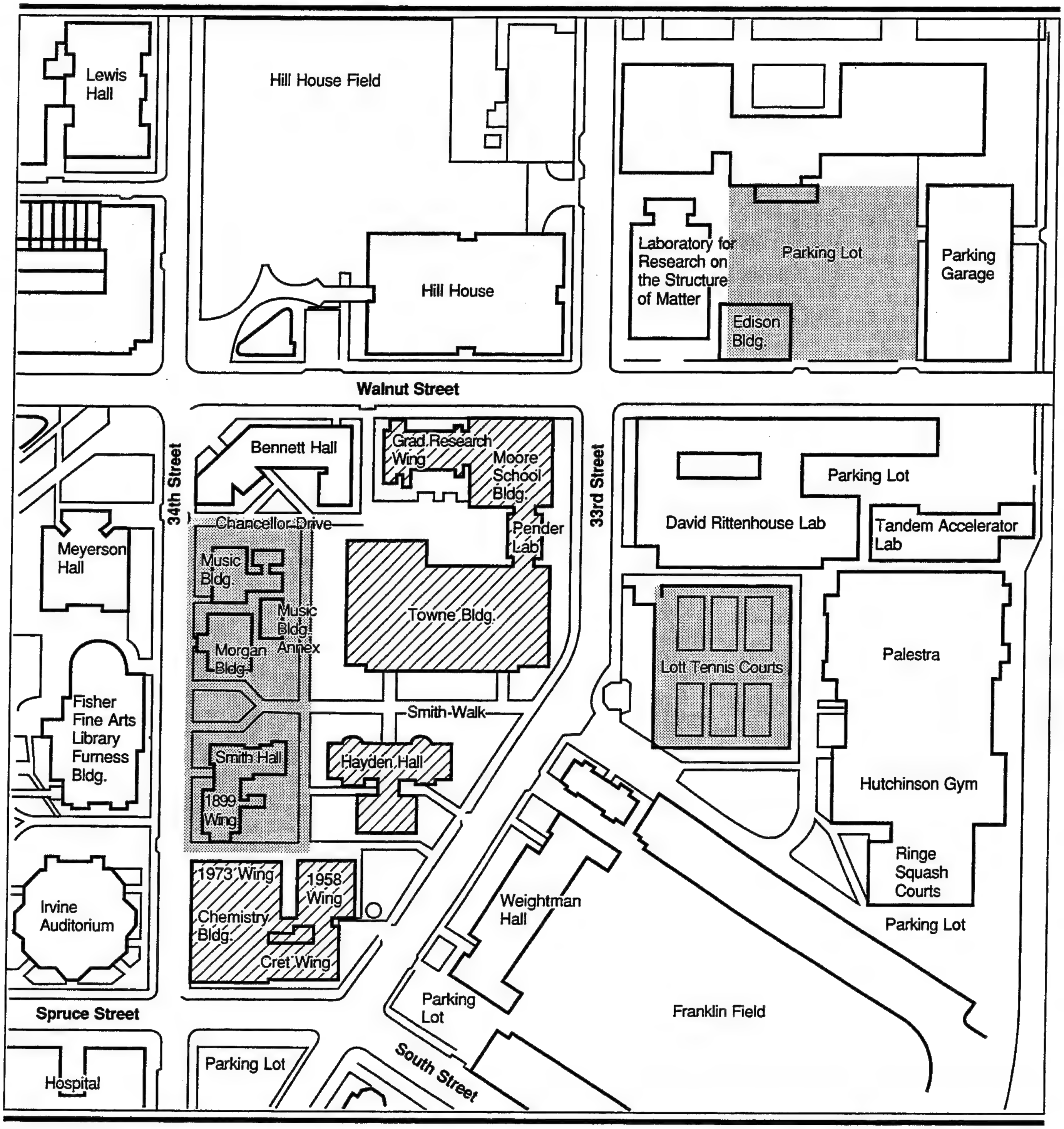
- During construction of the building
- After completion of the building

D1.2 EXISTING CONDITIONS

D1.2.1 Existing Roadway Network

The study area (project site) boundaries include Walnut Street to the north, Spruce Street to the south, 33rd Street to the east and 34th Street to the west. In the study area, Walnut Street is a one-way westbound roadway with three travel lanes and metered parking. Spruce Street is a four-lane, two-way roadway in the study area, running parallel to Walnut Street. The two north-south streets in the study area, 33rd and 34th Streets, run parallel to each other. Both are three lanes wide, and serve as a one-way pair with 33rd Street serving northbound traffic and 34th Street carrying southbound traffic.

Two heavily used pedestrian walks are situated in the study area. Smith Walk extends between 33rd and 34th Streets approximately halfway between Walnut Street and Spruce Street. On the west, a crosswalk links it with stairs leading to Locust Walk. On the east, a crosswalk links it with David Rittenhouse Laboratories and various athletic facilities.



EXPLANATION

Existing IAST Programs

Alternative Sites for New Construction

Alternative Sites

0 50 100 200 Feet

Source: Venturi, Scott, Brown and Associates, Inc., December 1990.

Figure D1.1-1

657-9168a 12/8/92

D1.2.2 Air Transportation

The Philadelphia International Airport is located within approximately six miles of the project site. It serves local and international flights daily. Convenient access to the airport is provided by highways and by rail. The Schuylkill Expressway (I-76) with an interchange at South Street, links the study area with the airport (via I-95). Rail transport to the airport is provided via SEPTA's regional commuter network with the closest station at 30th Street Station.

D1.2.3 Railroads

The Subway Surface Cars Routes 11, 13, 34 and 36 serve the study area with stops at the intersections of 37th and Spruce Streets, 36th and Sansom Streets and on 33rd Street between Market and Chestnut Streets. Also, the Market Frankford El has a station at the intersection of 34th and Market Streets. Finally, the 30th Street Station on Market Street serves Amtrak passenger trains and SEPTA's regional commuter rail.

D1.2.4 Existing Traffic Volumes

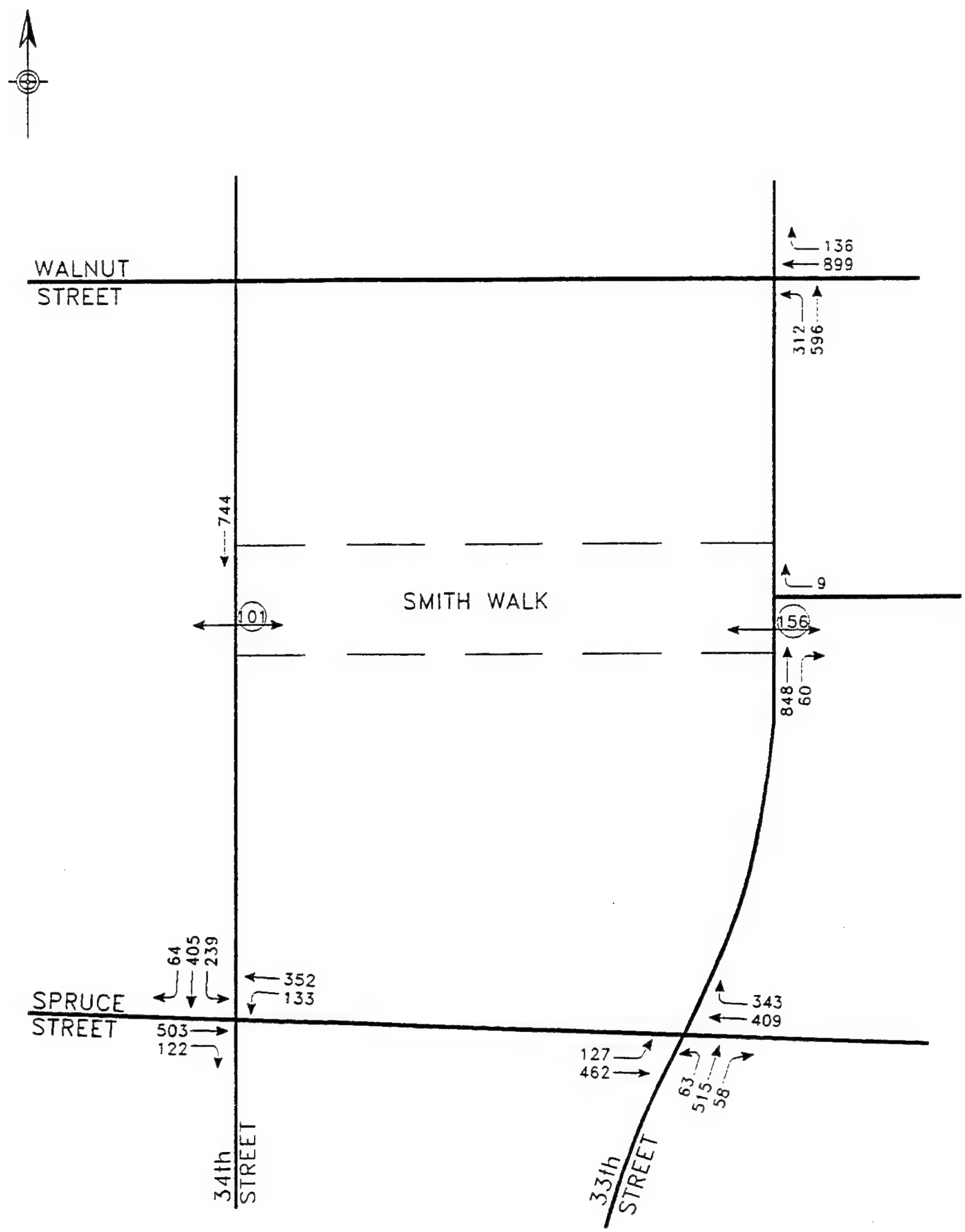
Intersections in urban areas are the most critical part of the roadway network in determining the capacity and levels of service in the area. Therefore, counts were conducted at the following intersections since they will be most impacted by the proposed building for any of the three alternative locations:

- Spruce Street and 34th Street - September 14, 1992
- Spruce Street and 33rd Street - September 15 and 16, 1992
- Walnut Street and 33rd Street - September 15, 1992

The traffic counts were conducted at the above-mentioned intersections between 6:00 A.M. and 6:00 P.M. The morning, noon, and afternoon peak hours were determined for each intersection and the results are summarized in Figures D1.2-1, D1.2-2 and D1.2-3. Traffic volumes from intersection to intersection do not always match due to the location of midblock driveways to parking lots, and the fact that the peak hours themselves can vary from intersection to intersection (i.e. 7:30-8:30 A.M. at one and 7:45-8:45 A.M. at another).

Seasonal and daily adjustment factors for the days the traffic counts were conducted were obtained from the Delaware Valley Regional Planning Commission. For Monday, September 14 the adjustment factor was 0.96 and for Tuesday, September 15 and Wednesday, September 15, the adjustment factors were 0.95 and 0.93 respectively. Since the counts were below 1.0, the counts were not adjusted so as to reflect worst case (highest volume) conditions. According to these factors volumes in the area on the days the counts were conducted are 4%-7% higher than under average traffic conditions.

Due to the proximity of the intersection of 34th Street and Spruce Street to the Hospital of the University of Pennsylvania, a detailed count was taken at this intersection, including the number of ambulances for each approach. Table D1.2-1 summarizes the results of this ambulance count.



(23) —PEDESTRIANS
NOTE: PEAK HOUR OF INDIVIDUAL INTERSECTIONS IS INDICATED

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FIGURE **D1.2-1**

EXISTING A.M. PEAK HOUR TRAFFIC VOLUMES

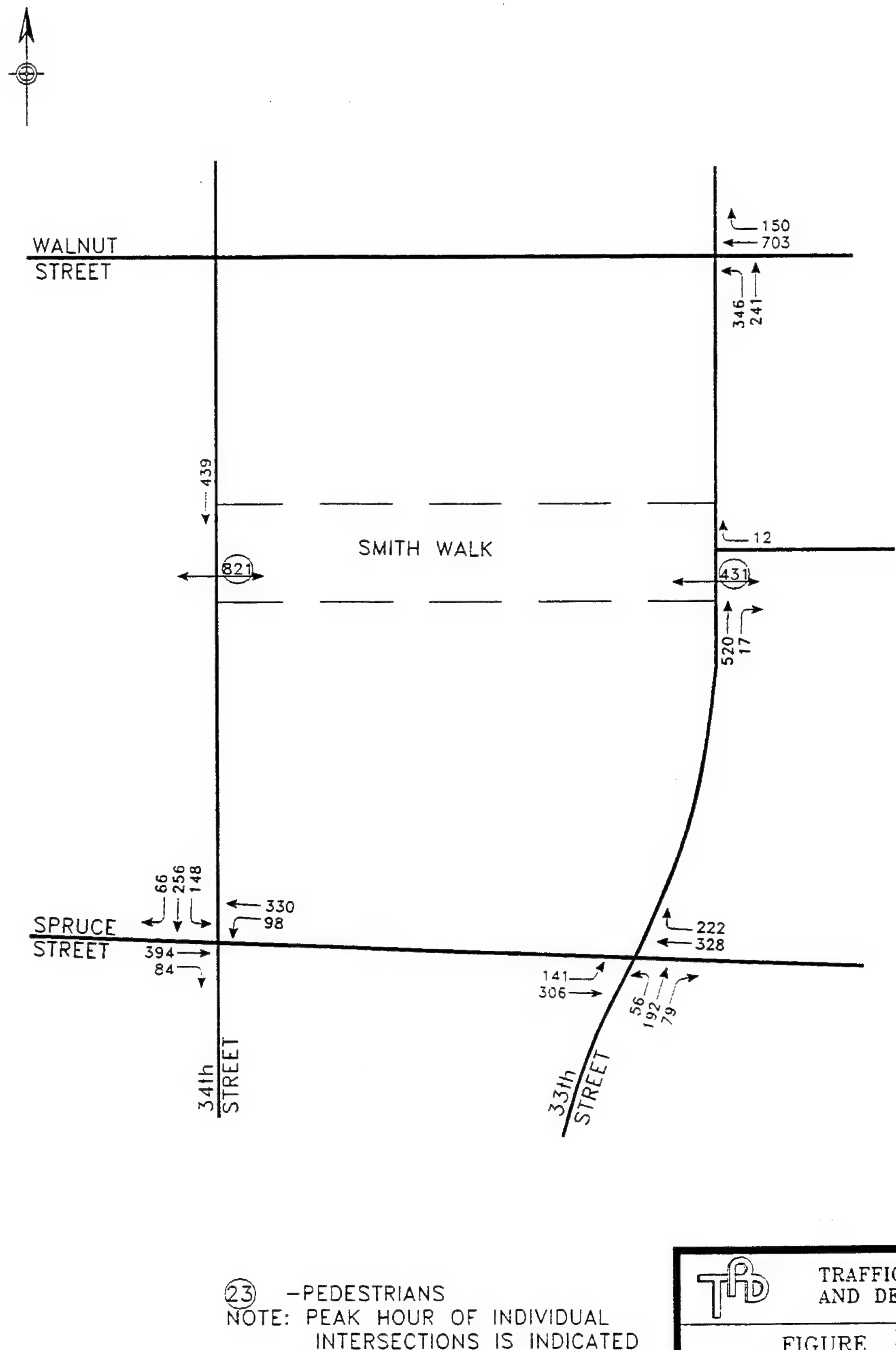

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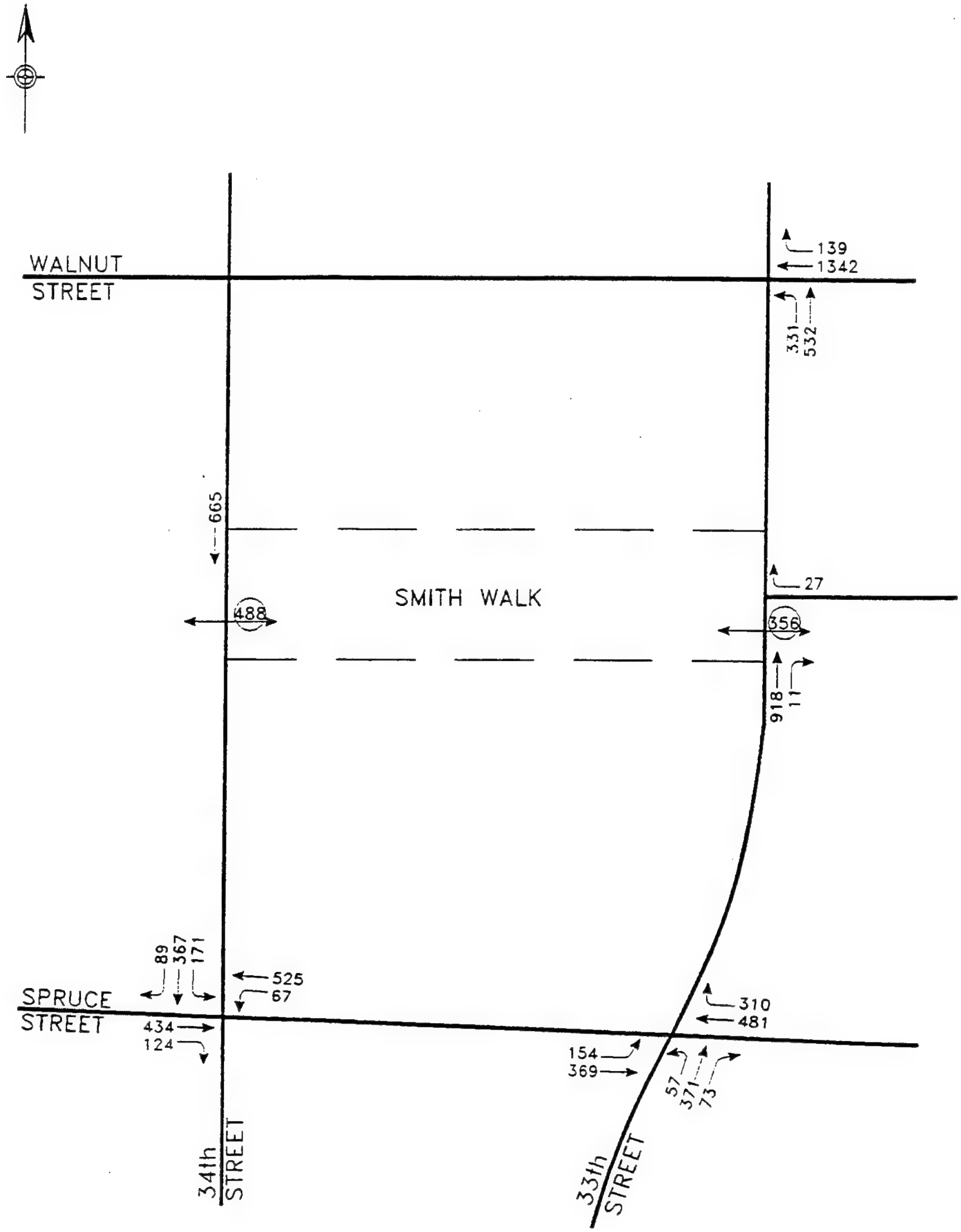
FIGURE D1.2-2

EXISTING NOON PEAK HOUR TRAFFIC VOLUMES



(23) —PEDESTRIANS
NOTE: PEAK HOUR OF INDIVIDUAL
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FIGURE D1.2-3

EXISTING P.M. PEAK HOUR
TRAFFIC VOLUMES

TABLE D1.2-1
AMBULANCE COUNT AT INTERSECTION OF 34TH STREET AND SPRUCE STREET

	Southbound 34th St.	**Westbound Spruce**	**Eastbound Spruce**
Time Period	Ambulances	Ambulances	Ambulances
6- 7 A.M.	0	0	1
7- 8 A.M.	0	2	1
8- 9 A.M.	0	3	4
9-10 A.M.	0	1	2
10-11 A.M.	0	0	1
11-12 noon	0	5	4
12- 1 P.M.	4	8	0
1- 2 P.M.	2	3	2
2- 3 P.M.	0	2	4
3- 4 P.M.	1	4	2
4- 5 P.M.	1	3	3
5- 6 P.M.	0	1	2

Counts were also conducted for the twelve hour time periods at the two pedestrian crosswalks on 34th and 33rd streets. The count on 34th Street was conducted on September 15, 1992 while the count on 33rd Street was conducted on September 16, 1992. The results of these counts for the three street peak hours are also given in Figures D1.2-1, D1.2-2 and D1.2-3 respectively. The actual pedestrian traffic peak hour may differ. After observation of the results, it was noticed that the pedestrian traffic volumes varied widely with the peaks occurring during the 15-minute periods during which classes would change at the nearby buildings. Tables D1.2-2 and D1.2-3 summarize the results of these counts at the crosswalks on 34th and 33rd Streets.

TABLE D1.2-2
PEDESTRIAN CROSSWALK COUNT ON 34TH STREET

Time Period	Southbound 34th Street: Cars	Southbound 34th Street: Trucks & Buses	Southbound 34th Street: Bicycles	Crosswalk: Pedestrians & Bicycles
6- 7 A.M.	313	8	0	25
7- 8 A.M.	571	20	4	53
8- 9 A.M.	683	22	9	363
9-10 A.M.	432	39	9	275
10-11 A.M.	401	47	9	389
11-12 noon	393	37	9	821
12- 1 P.M.	342	31	9	421
1- 2 P.M.	441	21	8	324
2- 3 P.M.	439	29	10	437
3- 4 P.M.	503	17	7	478
4- 5 P.M.	507	24	8	670
5- 6 P.M.	535	18	11	396

Average Daily Traffic (ADT) counts were provided to us by the Philadelphia Streets Department at the locations indicated on Table D1.2-4.

TABLE D1.2-3
PEDESTRIAN CROSSWALK COUNT ON 33RD STREET

Time Period	Southbound 33rd Street: Cars	Southbound 33rd Street: Trucks & Buses	Southbound 33rd Street: Bicycles	Crosswalk: Pedestrians & Bicycles
6- 7 A.M.	291	17	0	11
7- 8 A.M.	610	26	2	103
8- 9 A.M.	861	32	6	375
9-10 A.M.	546	47	5	247
10-11 A.M.	276	21	6	314
11-12 noon	487	33	7	431
12- 1 P.M.	402	34	8	285
1- 2 P.M.	454	43	10	583
2- 3 P.M.	497	38	5	649
3- 4 P.M.	645	24	6	458
4- 5 P.M.	859	23	8	397
5- 6 P.M.	791	14	9	441

TABLE D1.2-4
AVERAGE DAILY TRAFFIC COUNTS

Location	ADT (vehicles per day)
33rd Street (between Walnut and Spruce)	9,400
Walnut Street (between 33rd and 34th St.)	18,200
34th Street (between Chestnut and Walnut)	10,600
Spruce Street (between 34th and 38th St.)	14,500

D1.2.5 Capacity Analysis for Existing Conditions

Capacity analyses were conducted for all intersections examined according to the procedures in the Highway Capacity Manual, Special Report 209, 1985, as described in Appendix D1-1. The analyses were run using all correct factors for truck volumes, pedestrians, bus stops, etc. The results of the analyses for existing conditions are summarized in Figure D1.2-4.

As indicated, all three signalized intersections examined presently operate at very good levels of service (level B or better). As indicated in Appendix D1-1, at a level of service B, the average delay for each approach is between 5 and 15 seconds. Therefore, based on our analyses the average delay for each approach at all three intersections examined is less than 15 seconds.

D1.2.6 Existing Parking Conditions

Existing parking conditions were based on the Parking Study prepared by Barton Aschman Associates, Inc. in November, 1989 for the University of Pennsylvania and the University of Pennsylvania Medical Center. According to the projections made in their report based on 1988 counts, the 1992 parking supply is 6,814 spaces in the University campus and adjoining facilities. Furthermore, the 1992 parking demand is 6,033 spaces resulting in a surplus of 781 spaces.

D1.2.7 Accident Analysis

An accident investigation was conducted for the intersections examined. The number of accidents at each intersection for the most recent years for which data was available (1986 through 1990), was obtained from the Philadelphia Streets Department and is summarized in Table D1.2-5. Of the 224 accidents occurring at these three intersections during this five year time period, 19% involved trucks of all types. Furthermore, of the 224 accidents, 43% involved pedestrians or bicycles. Of the three study area intersections, 65% of the accidents occurred at the

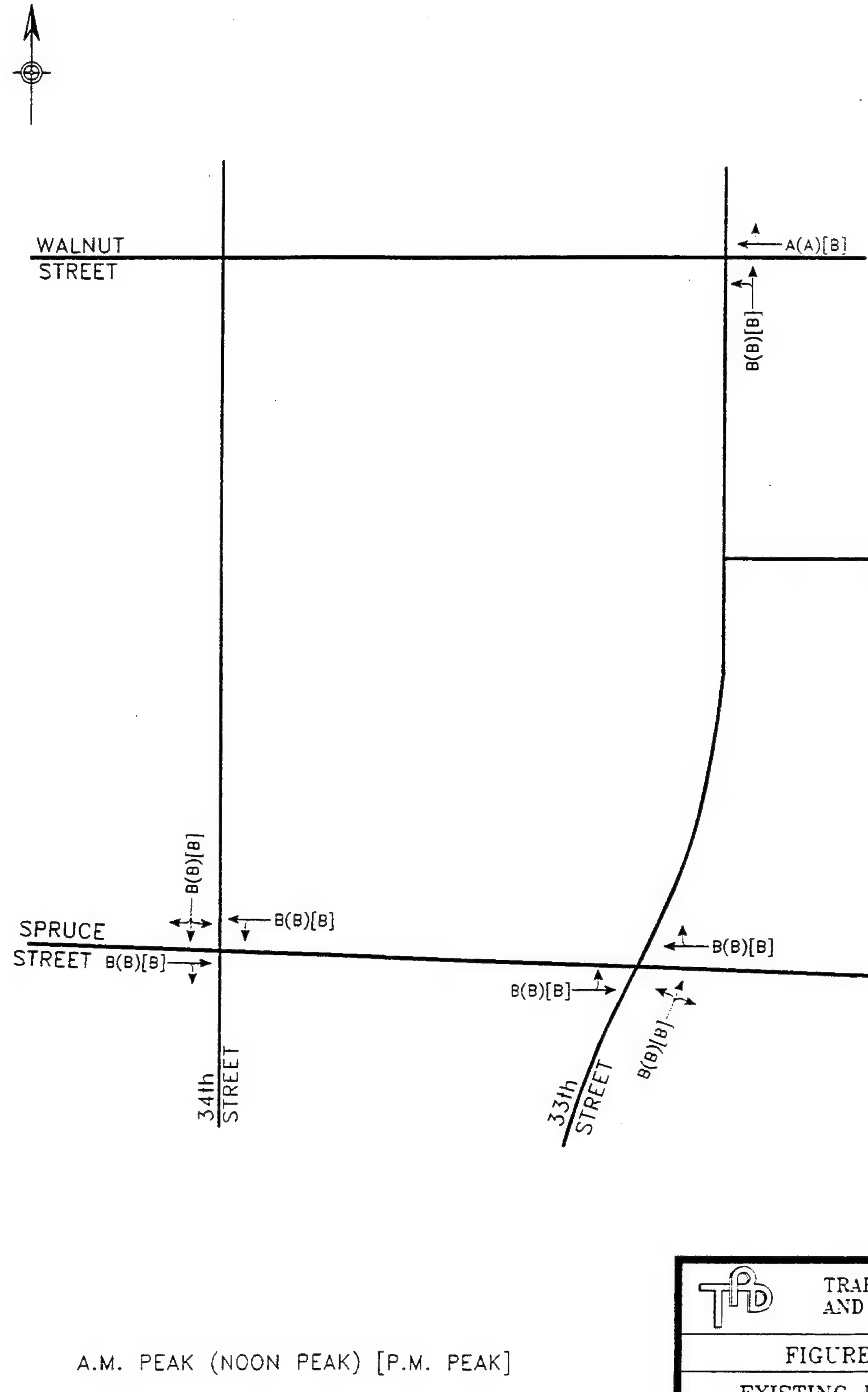

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FIGURE D1.2-4

EXISTING LEVELS OF SERVICE

intersection of 34th and Spruce Streets.

TABLE D1.2-5
ACCIDENT ANALYSIS

Intersection	1990	1989	1988	1987	1986
34th Street & Spruce Street	28	31	39	23	24
33rd Street & Walnut Street	4	2	9	12	15
33rd Street & Spruce Street/ South Street	7	9	11	6	4

D1.3 PROJECTED CONDITIONS DURING CONSTRUCTION

D1.3.1 Pre-construction Estimates

SAE Americon, the general contractors for the project, prepared the pre-construction estimates to determine the time frame for construction, number of construction employees, number of deliveries, etc. According to their projections, the project will start in March of 1993 and will be completed by October of 1994. Between August of 1993 and September of 1994, a staging area will be installed in front of the building, closing one lane of traffic. The number of construction workers will vary during the construction period with the maximum number of employees reaching 75 in the beginning stages of the project and decreasing to less than 25 by the end of the project. Construction will typically occur between 7:30 A.M. and 3:30 P.M. Furthermore, the maximum number of deliveries to the project site is expected to be no more than twenty daily. Deliveries will be limited during off peak hours.

D1.3.2 Trip Generation During Construction

Based on the estimates developed by SAE Americon, the peak hour trips generated by the site were developed. The following assumptions were made in these calculations:

- As a worst case (highest volume) condition, all employees will arrive in the study area in their own vehicle during the street A.M. peak hour although it is possible that many will carpool or vanpool from the offices of the construction firm.

- No deliveries will occur during the A.M. and P.M. peak hours. Five deliveries were assumed to arrive and depart the site during the noon peak hour.

- Five employee trips were assumed to leave the site during the P.M. peak hour, even though all construction should stop by 3:30 P.M.

Table D1.3-1 summarizes the trip generation for the site during the construction period.

TABLE D1.3-1
PROJECT SITE TRIP GENERATION DURING CONSTRUCTION

	Construction Trips
A.M. Peak Hour	
Enter	75
Exit	0
Total	75
Noon Peak Hour	
Enter	5
Exit	5
Total	10
P.M. Peak Hour	
Enter	0
Exit	5
Total	5

D1.3.3 Trip Distribution/Assignment of Construction Trips

The construction trips were distributed/assigned to the study area roadways based on the existing traffic patterns, the local road network, and the proposed building location. As explained earlier in the report, three alternative sites are being considered for the construction of the proposed building. Since the three possible sites are located within one block of each other, the employees will probably park in the same location regardless of which site is selected. Therefore the trip distribution/assignment of the trips on the local roadway network will be the same for all three locations. Table D1.3-2 identifies the directional distribution rates used in assigning these trips to the local highway network.

TABLE D1.3-2
DIRECTIONAL DISTRIBUTION RATES

Roadway	To	From
33rd Street	20%	15%
34th Street	15%	20%
Walnut Street	40%	30%
Spruce Street East	10%	20%
Spruce Street West	15%	15%

D1.3.4 Projected Traffic Volumes During Construction

Traffic volumes were developed for 1994 conditions during construction of the proposed project. As discussed in the previous section, traffic patterns on the roadway network should be the same regardless of which building site is selected. A 0.5% annual background growth factor was used for the next two years. This rate represents a worst case estimate for two reasons. One reason is that Philadelphia's population and employment has been declining in the 1980-1990 decade according to the U.S. Census. Furthermore, by November of 1994 there should be a 6% reduction in vehicle miles of travel (and thus close to a 6% reduction in vehicles as well) in the area according to the requirements of the 1990 Clean Air Act Amendments.

The projected traffic volumes indicated in Figures D1.3-1, D1.3-2 and D1.3-3 for A.M., noon, and P.M. peak hour conditions include the 0.5% annual background growth factor for two years and the traffic generated during construction of the proposed building.

D1.3.5 Capacity Analysis During Construction

In a road network, intersections are the critical component in the system. If the intersections have adequate capacity, so will the street segments linking the intersections. Therefore, capacity analyses were conducted for all intersections examined according to the procedures in the Highway Capacity Manual, Transportation Research Board, Special Report 209, 1985, as described in Appendix D1-1. Different roadway conditions will exist for each alternative site due to placement of the staging area at each. The assumptions described below were made with respect to the impact of each staging area on traffic operations:

- At the Proposed Action and Reuse of a Portion of Smith Hall site, a staging area will exist on the east side of 34th Street next to the construction site. For worst case conditions, it was assumed that the staging area would extend to the Spruce Street intersection thus limiting traffic to two southbound lanes at the intersection.

- At the LRSM parking lot site, a staging area will exist on the north side of Walnut Street next to the construction site. For worst case conditions, it was assumed that the staging area would extend to the 33rd Street intersection thus limiting traffic to two westbound lanes at the intersection.

- At the Lott Tennis Court site, a staging area will exist on the east side of 33rd Street next to the construction site limiting northbound traffic to two lanes. Unlike the other sites, this staging area is located closer to the middle of the block. Therefore, it will have no effect at the intersections north or south of the project. With the correct tapers and traffic control, three northbound lanes can be maintained at the intersections with Spruce Street and Walnut Street. Based on a review of the intersection capacity analyses, two northbound lanes past the staging area will be sufficient to accommodate traffic through the area and not degrade the level of service.

The analyses for projected conditions during construction are summarized in Figure D1.3-4.

The analyses indicated in Figure D1.3-4 include the results under each alternative. As shown, all intersections examined will continue to operate at good levels of service (level B or better) during construction of the proposed facility regardless of the location within the project site.

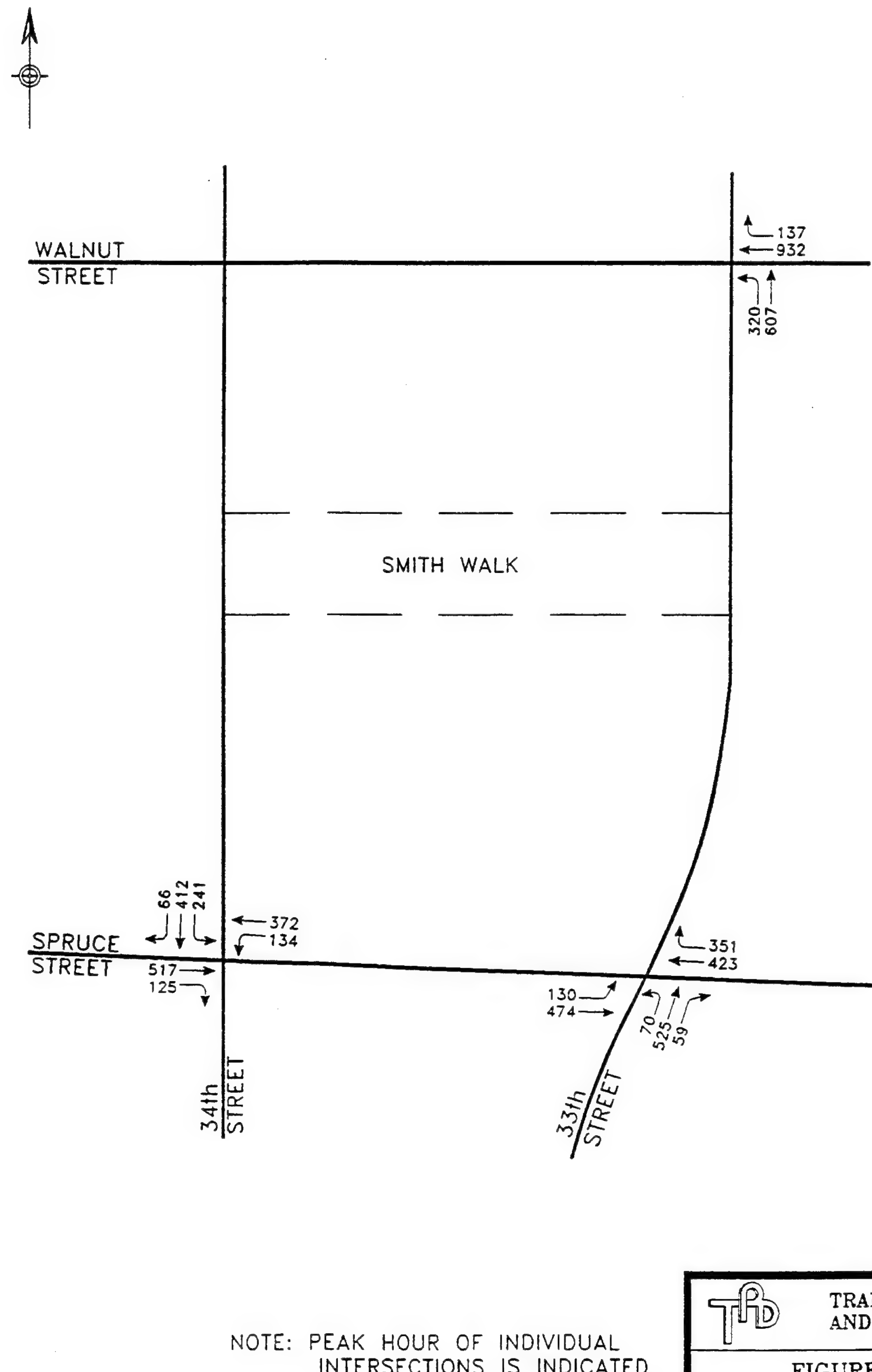

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FIGURE D1.3-1

PROJECTED A.M. PEAK HOUR TRAFFIC VOLUMES DURING CONSTRUCTION

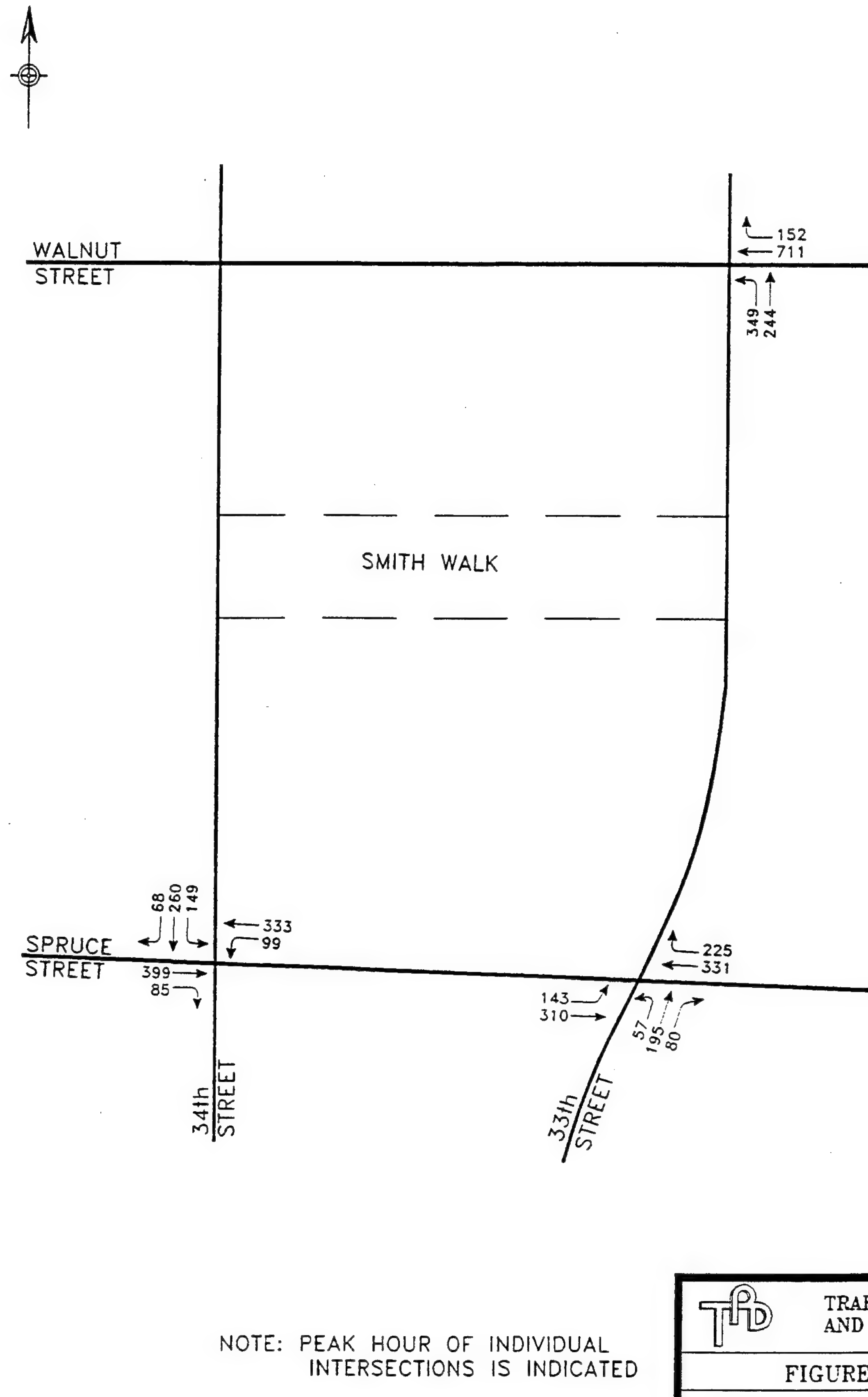

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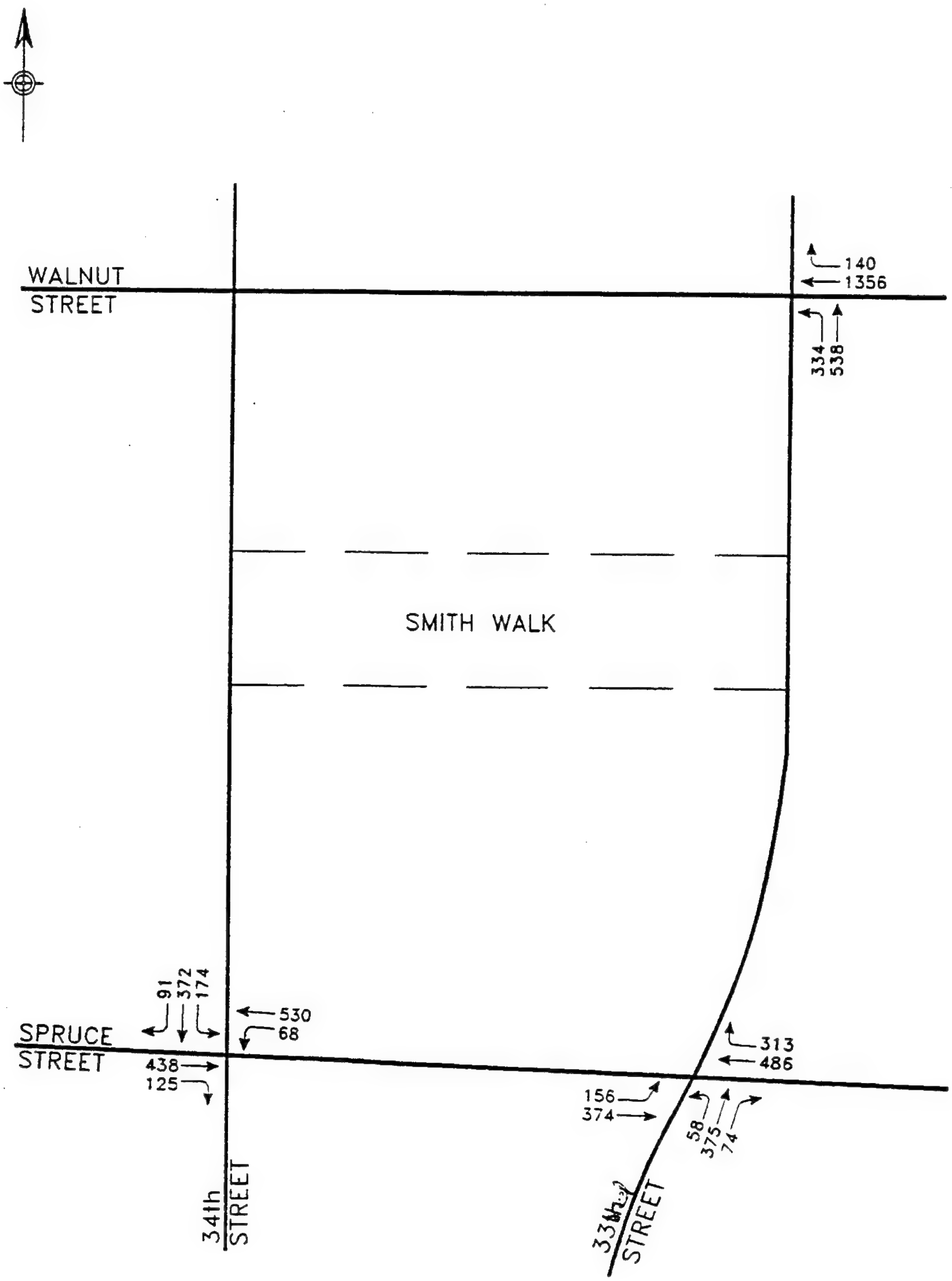
FIGURE D1.3-2

PROJECTED NOON PEAK HOUR TRAFFIC VOLUMES DURING CONSTRUCTION



NOTE: PEAK HOUR OF INDIVIDUAL
INTERSECTIONS IS INDICATED

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FIGURE D1.3-3

PROJECTED P.M. PEAK HOUR TRAFFIC VOLUMES DURING CONSTRUCTION

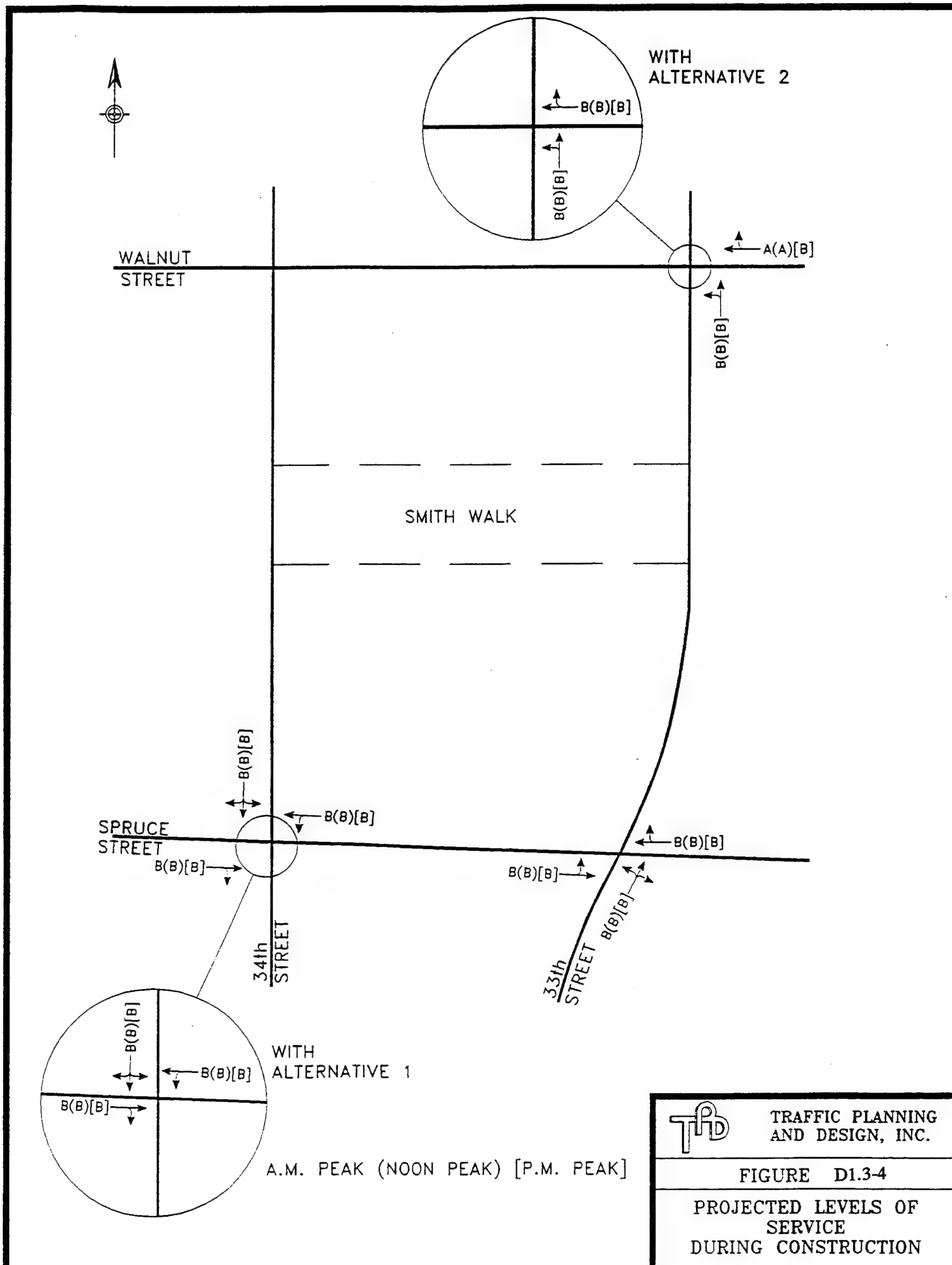

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FIGURE D1.3-4

PROJECTED LEVELS OF SERVICE DURING CONSTRUCTION

D1.3.6 Parking Conditions During Construction

Projected parking conditions were based on the Parking Study prepared by Barton Aschman Associates, Inc. in November, 1989 for the University of Pennsylvania and its Medical Center. Their projections, based on 1988 counts, determined that the 1994 parking supply will be 6,388 spaces in the University campus and adjoining facilities. While the study took into account the loss of 426 spaces after construction of a new student center which has since been postponed to beyond 1994, it did not account for a new parking garage at 38th and Walnut Streets adding 600 new spaces. The new garage will result in a 1994 parking supply of 6,988 spaces. Furthermore, the 1994 parking demand according to the Parking Study is 6,161 spaces. Therefore, a surplus of 827 spaces will exist prior to construction of the facility. This parking surplus will be more than adequate to handle the traffic generated during the construction period. It is estimated that parking demand will increase by a maximum of 75 spaces if all construction employees drive to the site individually. This is highly unlikely as it is common practice to carpool or have a company van drop off employees at the project site.

D1.3.7 Impacts of Proposed Alternatives During Time Periods Analyzed

Regardless of the location selected for the proposed building, the traffic generated during construction will cause less than a 2.5% increase in traffic on the roadways examined. All approaches at the intersections examined will continue to operate at good levels of service (level B or better) during the A.M., noon and P.M. peak hours even in the unlikely event that the staging areas extend into adjacent intersections. Furthermore, there will be no degradation of level of service in the road segments next to the staging areas.

If any site had an impact on emergency response times to the Hospital of the University of Pennsylvania and the Childrens Hospital of Philadelphia, both of which are located south of the site on 34th Street, it would be the staging area for the Smith Hall site (Proposed Action and Reuse of a Portion of Smith Hall) which is located on 34th Street which is a direct route to the hospitals. Based on the intersection delay, level of service analyses, and ambulance counts, emergency response times should not be adversely impacted by construction at any of the sites. Emergency response times will increase by a maximum of 2.2 seconds along 34th Street while the staging area is in place; however, as shown in Table D1.2-1, ambulance approaches are predominantly from Spruce Street.

Based on a review of the historical accident records, 19% of all accidents involved a truck of any type. With construction on-going at the University facilities during this time period, it is unlikely that the rate of accidents involving trucks will increase due to construction. However, of the three sites, the one to have the most likely impact on the accident rate is the Smith Hall site. Of the accidents occurring at the three study area intersections, 65% occurred at the intersection of 34th and Spruce Streets located just south of the site. Forty-three percent of the accidents in the study area involved pedestrians or bicycles. Of the five locations at which pedestrian counts were completed, the highest volumes were recorded on 34th Street on either side of the Smith Hall site at Locust/Smith Walk and at Spruce Street.

Although levels of service along Walnut Street would be excellent, closing of a lane at any location obviously has some impact. The Philadelphia Department of Streets and the Pennsylvania Department of Transportation may not want to have a staging area located along Walnut Street which is a major arterial for traffic exiting the city. Therefore, it may be prefarable to locate the staging area on the east side of 33rd Street north of the LRSM building to avoid this potential impact.

D1.3.8 Impact During Special On-Campus Events

The lane closure due to construction of the proposed building may have more of an impact in the area during special events depending upon the amount of automobile traffic generated by each. While the lane closures are in effect, five football games would be hosted by Penn on Saturdays at Franklin Field located at the southeast corner of 33rd and Spruce Streets. Based on past attendance records, a maximum of 30,000 people including students would attend. Graduation ceremonies for the Penn Class of 1994 would also be held at Franklin Field on a Monday in May. During this same time period, a total of approximately twelve basketball games would be hosted by Penn in the Palestra located midblock on 33rd Street between Spruce and Walnut Streets. The Palestra has a capacity of 9,000 people but attendance levels including students would approach capacity only once or twice per year. Irvine Auditorium, with a capacity less than half that of the Palestra is located on the northwest corner of 34th and Spruce Streets. A few concerts are held here each year and are attended by students as well as the general public.

Since there is little parking immediately adjacent to any of these facilities and many of the attendees are students, most of the traffic during these events would be pedestrian traffic. In fact, a relatively small proportion of the attendees would drive through any of the intersections analyzed in this report. The second alternative site location at the Lott Tennis Court site, would have the most impact during these events as the staging area on 33rd Street would eliminate the sidewalk on the east side of 33rd Street, and thus impact pedestrian traffic flow to/from the Palestra and Franklin Field. However, the sidewalk on the west side of 33rd Street has sufficient capacity to handle the increase in pedestrian traffic flows so this does not represent a significant impact.

D1.3.9 Impact During Special Civic Center Events

Many special events are held at the Civic Center and Convention Center located just south of the study area near 34th Street and Civic Center Boulevard. These events include LaSalle University basketball games, professional wrestling events, some concerts, etc. at the Civic Center and the Flower Show, the Car Show, the Home Show, etc. at the Convention Center. The Civic Center is used primarily at night and on weekends for a total of 200 events per year but is also heavily used during the day for major events such as the Flower Show. The March Flower Show is the most heavily attended event held at the Civic Center with 1/4 million visitors over the course of nine days.

Several parking garages are provided on or adjacent to the Convention Center site. Therefore, most attendees drive straight to the Convention Center area before looking for parking. While the traffic consultant's opinion is that none of the sites would adversely impact traffic to and from the Civic Center facilities, the Smith Hall site would have the most impact of the three sites since it is located closest to the Convention Center area and its staging area would be located on a direct route to these facilities.

D1.3.10 Mitigation Measures During Construction

Several mitigation measures should be applied during construction of the proposed building to minimize the impact on the surrounding roadway network. These measures should include the following:

- The closing of a lane on the adjacent roadway for construction staging should be kept to a minimum and be timed to affect only one football season, one basketball season, one graduation ceremony and one Flower Show.
- Truck deliveries during construction should not occur between 7:00 - 9:00 A.M. and 4:00 - 6:00 P.M. to minimize the traffic impact on the local road network.
- Contractors should encourage the use of carpooling or vanpooling to minimize the impact of employee traffic in the area.
- Proper work zone traffic control devices in accordance with Pennsylvania Department of Transportation standards should be placed on the roadways in advance of the construction site and staging areas to efficiently merge traffic on the remaining lanes.
- If the Smith Hall site is selected, Smith Walk should remain open throughout the construction period, in order to accommodate the heavy pedestrian traffic.

D1.4 PROJECTED CONDITIONS AFTER COMPLETION OF THE PROJECT

D1.4.1 Trip Generation of Proposed Building

The proposed building will be used as an extension of the existing Chemistry Building at the corner of 34th Street and Spruce Street. Based on information provided to us by the University of Pennsylvania, it is expected that 290 additional graduate students and 10 new staff members are expected to be added as a result of the new building.

In developing the trip generation for the proposed building it was assumed that 10% of the graduate students and all the staff members will drive to the University during the A.M. and P.M. peak hours. This is a worst case (highest volume) considering that most students and some faculty members live in the area and walk rather than drive. Based on the above assumption, the trip generation for the new building was developed and is indicated in Table D1.4-1.

TABLE D1.4-1
PROJECT SITE TRIP GENERATION

	Trips
A.M. Peak Hour	
Enter	39
Exit	0
Total	39
Noon Peak Hour	
Enter	5
Exit	5
Total	10
P.M. Peak Hour	
Enter	0
Exit	39
Total	39

D1.4.2 Trip Distribution/Assignment

The trips were distributed/assigned to the study area roadways based on the existing traffic patterns, the local road network, and the building location. As explained earlier in the report, three alternative sites are being considered for the construction of the proposed building. Since all three possible sites are located within one block of each other, the employees will probably park in the same location regardless of which site is selected. Therefore, the trip distribution/assignment of the trips on the local roadway network is expected to be the same for all three locations. The same directional distribution rates used in the "Projected Conditions During Construction" section were used in assigning these trips to the local highway network.

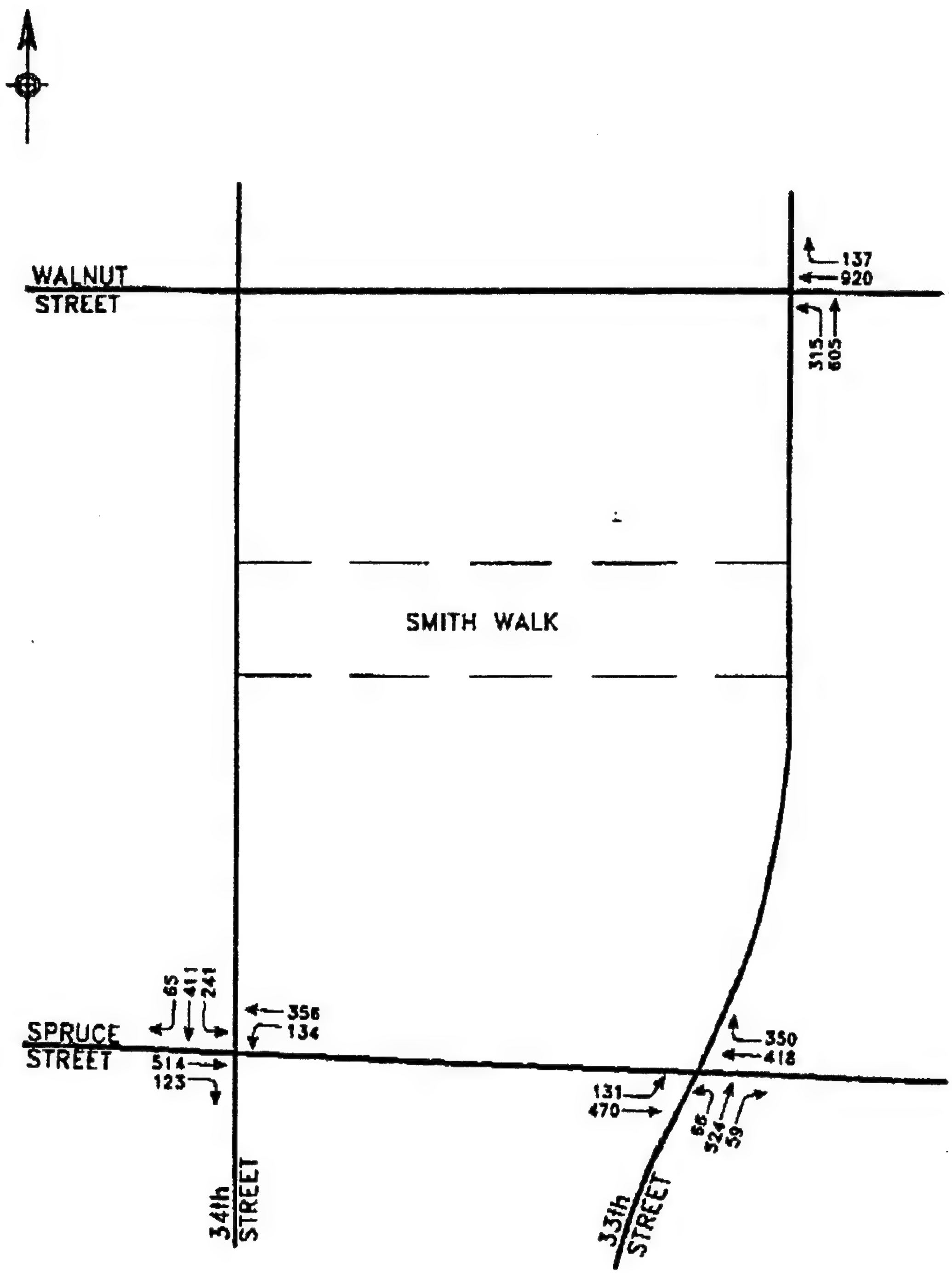
D1.4.3 Projected Traffic Volumes

Traffic volumes were developed for 1994 conditions after construction of the proposed project. As discussed in the previous section, traffic patterns on the roadway network should be the same regardless of which building site is selected. Existing traffic volumes were increased by the same worst case 0.5% annual background growth factor as was used in Section D1.4.4 for the next two years until completion of the project in 1994.

The projected traffic volumes indicated in Figures D1.4-1, D1.4-2 and D1.4-3 include the 0.5% annual background growth factor for two years and the traffic generated after construction of the proposed building.

D1.4.4 Capacity Analysis After Construction

Capacity analyses were conducted for all intersections examined according to the procedures in the Highway Capacity Manual, Special Report 209, 1985, as described in Appendix D1-1. The results of the analyses for projected conditions after construction are summarized in Figure D1.4-4. All three intersections examined will



NOTE: PEAK HOUR OF INDIVIDUAL INTERSECTIONS IS INDICATED

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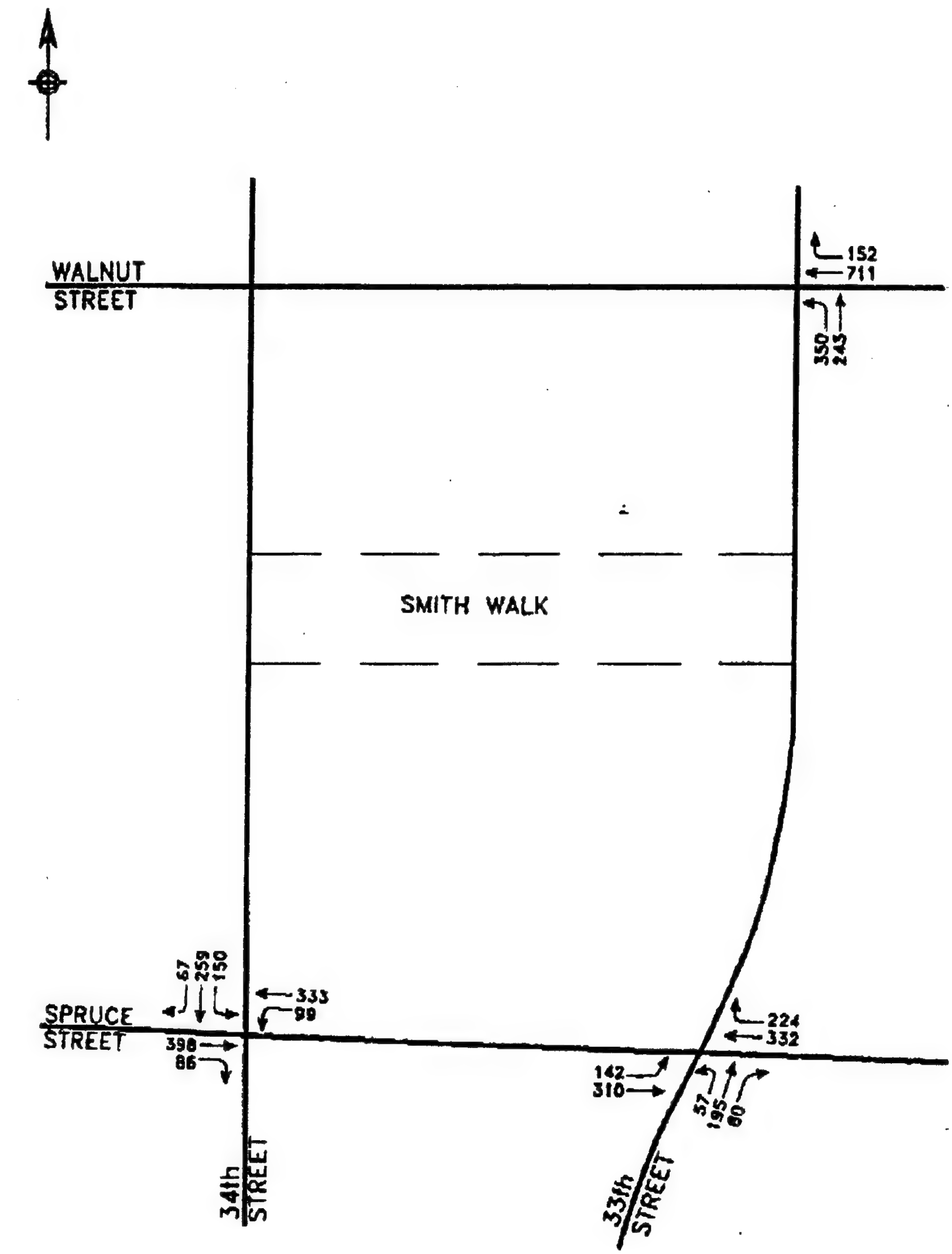
FIGURE D1.4-1

PROJECTED A.M. PEAK HOUR TRAFFIC VOLUMES AFTER CONSTRUCTION



NOTE: PEAK HOUR OF INDIVIDUAL INTERSECTIONS IS INDICATED

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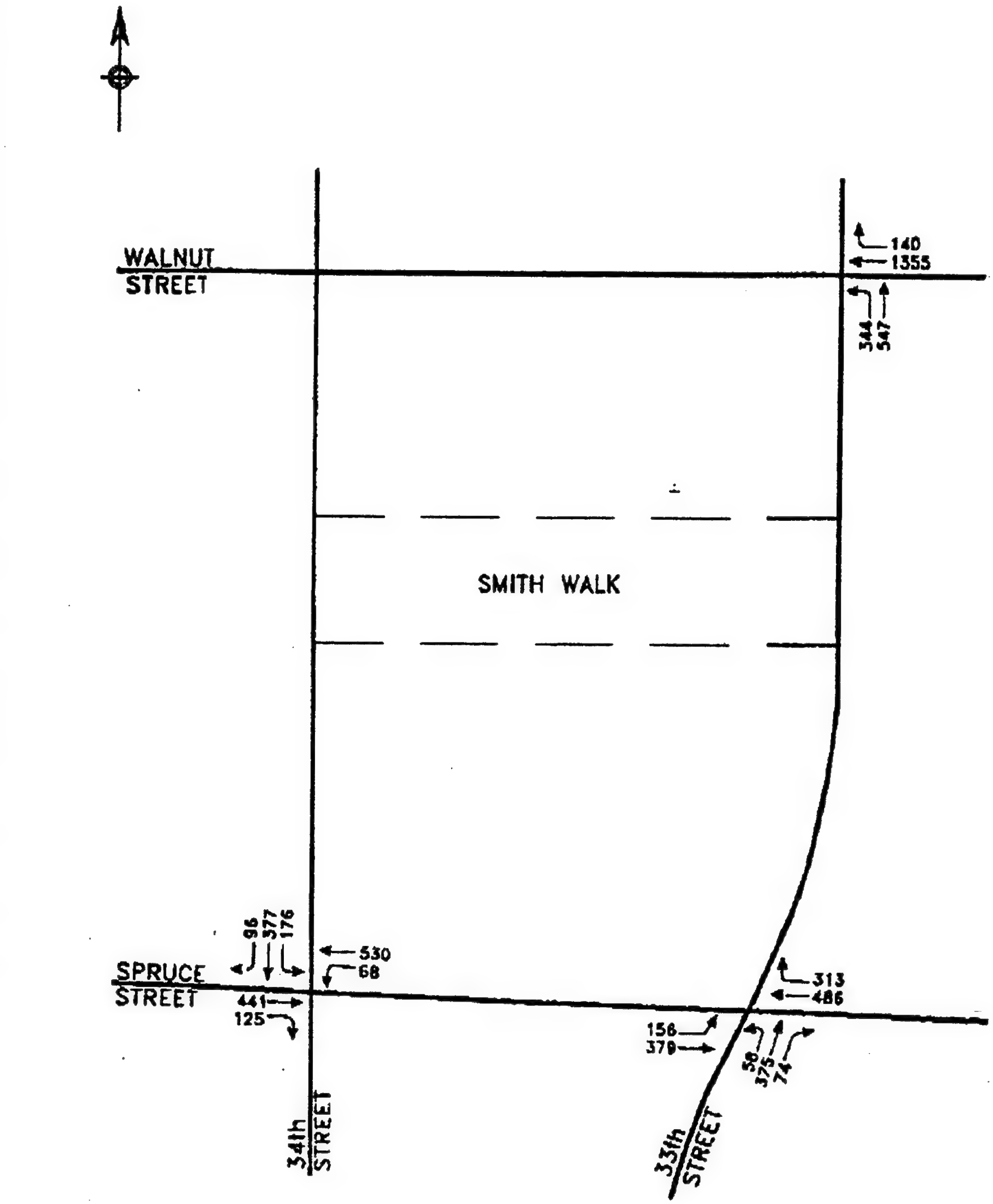
FIGURE D1.4-2

PROJECTED NOON PEAK HOUR TRAFFIC VOLUMES AFTER CONSTRUCTION



NOTE: PEAK HOUR OF INDIVIDUAL INTERSECTIONS IS INDICATED

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FIGURE D1.4-3

PROJECTED P.M. PEAK HOUR TRAFFIC VOLUMES AFTER CONSTRUCTION

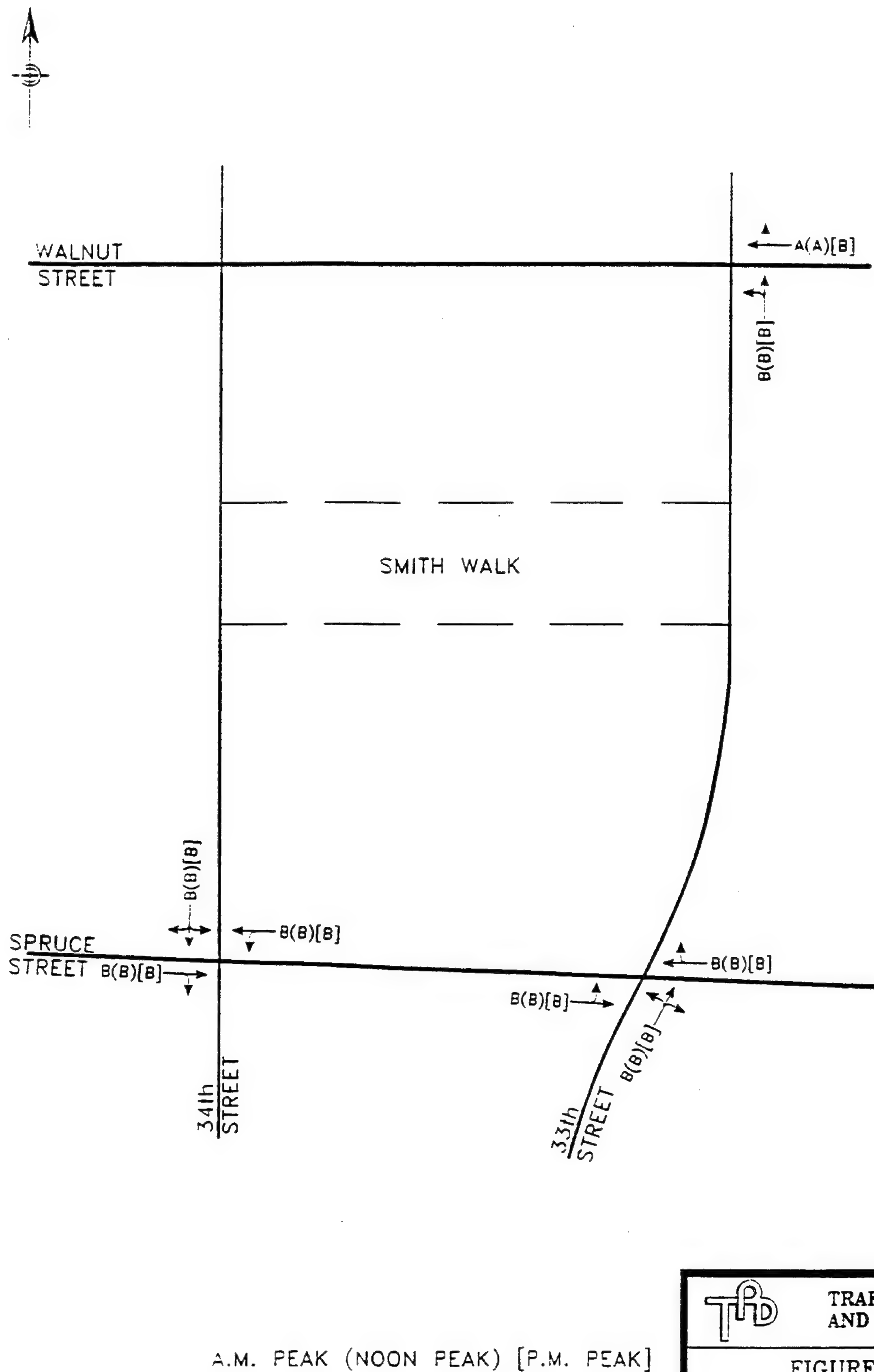

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FIGURE D1.4-4

PROJECTED LEVELS OF SERVICE AFTER CONSTRUCTION

continue to operate at good levels of service (level B or better) after construction of the proposed building regardless of the location selected.

D1.4.5 Projected Parking Conditions

As discussed in Section D1.3.6, the 1994 parking supply of 6,988 spaces in the University campus and adjoining facilities will exceed the parking demand of 6,161 spaces by 827 spaces. which will be more than adequate to handle the 39 space demand projected for this site.

D1.4.6 Impact of the Proposed Building

Regardless of which site is selected, there will be no adverse impact from the proposed building, once completed, from a traffic engineering point of view. The available parking supply will not be adversely impacted. The building will cause less than a 0.2% increase in traffic volumes in the area. Intersection delays and levels of service will not be impacted by the building. Therefore, there will be no change in emergency response time to the two hospitals. With occupancy, there should be no increase in accident potential in the area. With occupancy, special events on-campus and at the nearby Convention Center complex will not be adversely impacted.

APPENDIX D1-1

CAPACITY ANALYSIS FOR SIGNALIZED INTERSECTIONS

CAPACITY ANALYSIS FOR SIGNALIZED INTERSECTIONS

The methodology and terminology used in the capacity analysis of signalized intersections are described in the 1985 Highway Capacity Manual (Special Report No. 209) published by the Transportation Research Board, which establishes a system by which intersections and roadways are analyzed for their ability to serve traffic volumes.

Level of Service for signalized intersections is defined in terms of delay. Level of Service criteria are stated in terms of the Average Stopped Delay per vehicle for the peak 15-minute period within the hour analyzed. The criteria for the various level of service designations are given in the following Table A.

TABLE A
LEVEL OF SERVICE CRITERIA FOR SIGNALIZED INTERSECTIONS

Level of Service	Stopped Delay Per Vehicle (sec)
A	5.0 or less
B	5.1 to 15.0
C	15.1 to 25.0
D	25.1 to 40.0
E	40.1 to 60.0
F	60.0 or greater

Level-of-Service A describes operations with very low delay, i.e., less than 5.0 seconds per vehicle. This occurs when the progression is extremely favorable, and most vehicles arrive during the green phase. Most vehicles do not stop at all. Short cycle lengths may also contribute to low delay.

Level-of-Service B describes operations with delay in the range of 5.1 to 15.0 seconds per vehicle. This generally occurs with good progression and/or short cycle lengths. More vehicles stop than for Level-of-Service A, causing higher levels of average delay.

Level-of-Service C describes operations with delay in the range of 15.1 to 25.0 seconds per vehicle. These higher delays may result from fair progression and/or longer cycle lengths. Individual cycle failures may begin to appear in this level. The number of vehicles stopping is significant at this level, although many still pass through the intersection without stopping.

Level-of-Service D describes operations with delay in the range of 25.1 to 40.0 seconds per vehicle. At Level D, the influence of congestion becomes more noticeable. Longer delays may result from some combination of unfavorable progression, long cycle lengths, or higher volume to capacity ratios. Many vehicles stop, and the

proportion of vehicles not stopping declines. Individual cycle failures are noticeable at this level.

Level-of-Service E describes operations with delay in the range of 40.1 to 60.0 seconds per vehicle. This is considered to be the limit of acceptable delay. These high delay values generally indicate poor progression, long cycle lengths, and high volume to capacity ratios. Individual cycle failures are frequent occurrences at this level.

Level-of-Service F describes operations with delay in excess of 60.0 seconds per vehicle. This is considered to be unacceptable to most drivers. This condition often occurs with oversaturation, i.e., when arrival flow rates approach or exceed the capacity of the intersection. Poor progression and long cycle lengths may also be major contributing causes to such delay levels.

In the determination of the Level of Service, each approach of the intersection is considered individually and a Level of Service computed for each based on factors that are dependent on terrain, population, location as to urban or rural, one or two-way street configuration approach width, parking regulations, number of lanes, and amount of through traffic. A summary tabulation of these factors follows.

Geometric Conditions	Area Type Number of Lanes Lane Widths, ft. Grades, % Existence of Exclusive LT or RT lanes Length of Storage Bay, LT or RT lanes Parking Conditions
Traffic Conditions	Volumes by Movement Peak-Hour Factor Percent Heavy Vehicles Conflicting Pedestrian Flow Rate, peds/hr. Number of Local Buses Stopping in Intersection Parking Activity, pkg. maneuvers/hr. Arrival Type
Signalized Conditions	Cycle Length, sec. Green Times, sec. Actuated vs. Pretimed Operation Pedestrian Push-Button Minimum Pedestrian Green Phase Plan

In evaluating an intersection for its Level of Service, all factors mentioned above have a direct bearing on the outcome. To perform a complete analysis, all these details must be known and used.

APPENDIX E

E
EXPOSURE ASSESSMENT

SECTION 1

INTRODUCTION

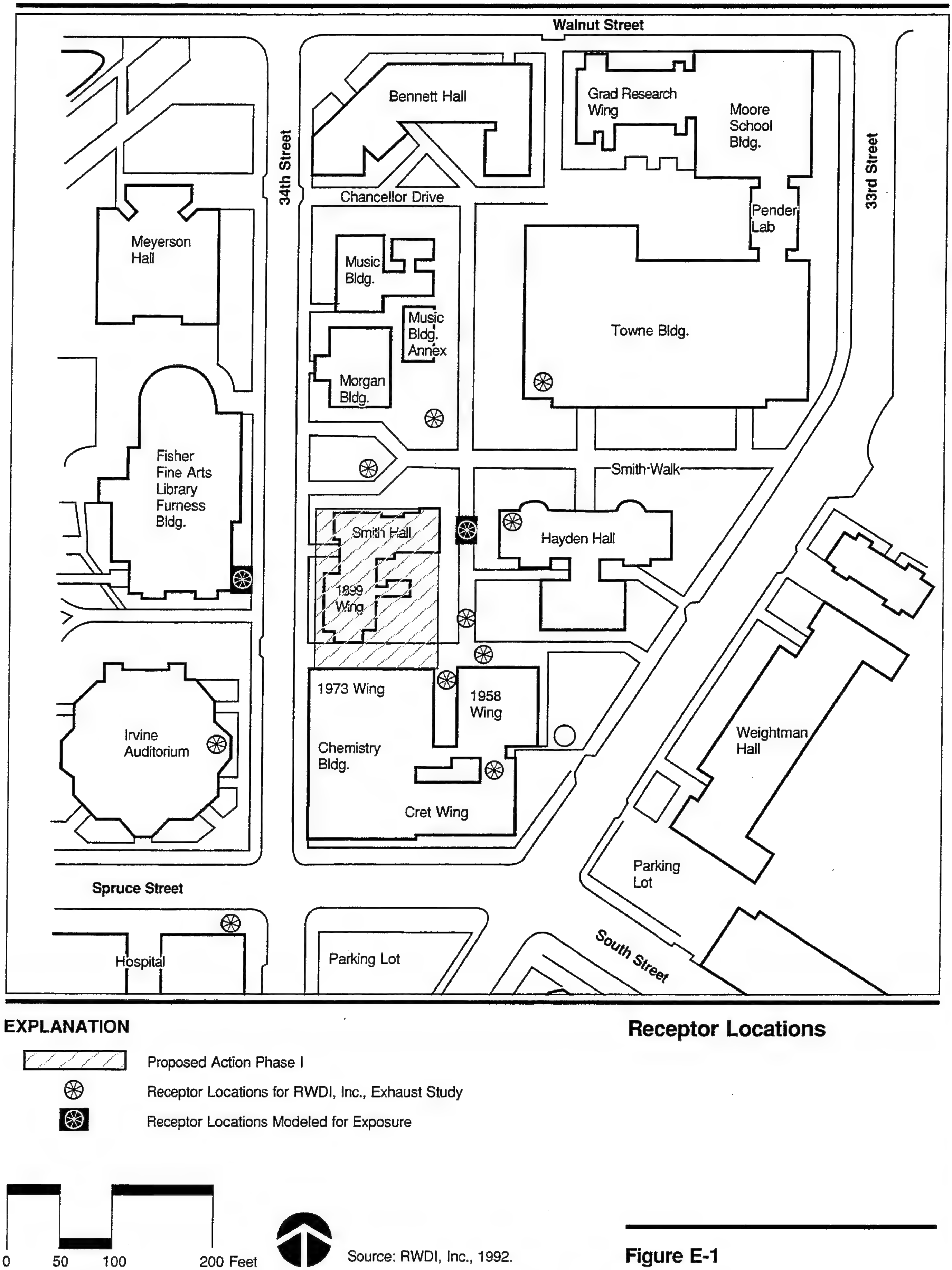
This exposure assessment addresses potential accidental chemical releases at the proposed Institute for Advanced Science and Technology (IAST) facility at the University of Pennsylvania campus in Philadelphia, Pennsylvania. The proposed IAST facility would be located on the eastern campus of the University of Pennsylvania immediately surrounded by other campus facilities and buildings. Figure E-1 shows the location of the proposed IAST facility.

Potential accidental release scenarios have been developed for ten chemicals that are currently stored at the university and may likely be used at the IAST facility. These chemicals are of concern due to their potential to result in acute and/or carcinogenic health effects upon exposure. The purpose of the following exposure assessment is to identify potential acute health effects to passersby on the street, and acute and/or carcinogenic health effects to potential nearby residents, resulting from releases of the chemicals of concern from the IAST facility.

The topics discussed in this report include:

- Identification of the chemicals of concern
- Development of release/exposure scenarios
- Air emission and dispersion modeling
- Evaluation of potential health risks
- Conclusions

These topics are discussed in more detail in the sections that follow.



Source: RWDI, Inc., 1992.

Receptor Locations

Figure E-1

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SECTION 2

CHEMICALS OF CONCERN AND EXPOSURE SCENARIOS

This section identifies the chemicals of concern, and evaluates how an individual nearby the laboratory may potentially be exposed to these chemicals through an accidental release. The release and migration of the chemicals, as well as potential exposure routes, are discussed.

2.1 CHEMICALS OF CONCERN

Ten chemicals were evaluated in this assessment: acrylonitrile, bromine, chloroform, hexane, hydrazine, hydrocyanic acid, hydrofluoric acid, hydrogen chloride, phosgene, and trichloroethylene. These chemicals are currently stored at the University's chemical laboratories and are likely to be used within the University's IAST facility. These chemicals were selected for analysis based on an evaluation of their toxicity, physical and chemical characteristics, and stored quantity. These ten chemicals have been identified as representing the range of potential acute and/or chronic health hazards to the population outside the laboratory environment in the event of an accidental release.

The chemicals of concern are listed in Table 2-1. The volume or weight associated with each chemical is based on the largest container of the chemical currently stored at the University. This information was obtained from an inventory of stocked chemicals at the University. The chemicals and their quantities as listed Table 2-1 were used to model an accidental release, and to estimate maximum exposure levels for the selected receptors.

2.2 EXPOSURE SCENARIOS

Potential exposure to the chemicals of concern involves not only an accidental release of the chemical, but the migration of the chemical to points of contact with potential receptors

Table 2–1

CHEMICALS OF CONCERN

Compounds	State	Weight or Volume	
Acrylonitrile [a]	Liquid	8	lbs.
Bromine	Liquid	8.2	lbs.
Chloroform [a]	Liquid	26.2	lbs.
Hexane	Liquid	10	gallons
Hydrazine [a]	Liquid	4.4	lbs.
Hydrocyanic Acid	Liquid	1	lb.
Hydrofluoric Acid	Liquid	1	liter
Hydrogen Chloride	Gas	3.4	lbs.
Phosgene	Liquid	21	lbs.
Trichloroethylene [a]	Liquid	1	quart

[a] The U.S. EPA classifies these chemicals as probable human carcinogens.

(i.e., passersby and nearby residents). Thus, the exposure scenarios for each of the chemicals of concern consists of the identification of a release scenario, migration pathways, and potential receptors, which are discussed in the following subsections.

2.2.1 Release Scenario

An accidental release was evaluated in this health risk assessment. In the accident scenario, the entire quantity of the largest single container of a chemical stored in the laboratory was assumed to spill and to volatize for a period of 15 minutes, after which time the remaining material was contained and cleaned up. The volatized portion of the compound was then assumed to be released to the atmosphere via the fume hood and then migrate to the street and surrounding buildings. The University Chemical Hygiene Plan provides a laboratory user/occupant with guidance to minimize risks associated with everyday use of chemicals and how to respond in the event of an accidental spill. Because of the engineering and risk management programs followed by the University of Pennsylvania, potentially hazardous amounts of chemicals are not likely to be released to the environment from facility activities.

2.2.2 Migration Pathways

In the event of an accidental release from the proposed IAST facility, assessment of potentially exposed receptors included an evaluation of possible migration pathways of the chemicals of concern. The chemicals of concern were assumed to be released in the form of a gas, or a liquid which evaporates into a gas. Two of the nine chemicals stored as a liquid, hydrocyanic acid and hydrofluoric acid, would be released in the form of the gases hydrogen cyanide and hydrogen fluoride, respectively. Thus, throughout the remainder of this report, these two chemicals will be referred to and assessed in the gaseous form.

Once the gaseous chemical is released to the environment outside the laboratory through the fume hoods and roof vents, the migration of the gases would be determined by the wind flow pattern in the area surrounding the IAST building. Potential receptors were identified

initially by numerical assessment (computer modeling). Because of the complex windflow in this area caused by the density of buildings, a conservative computational method was used. The method is described in Chapter 14 of the 1989 ASHRAE Handbook of Fundamentals.

Assessment of potentially exposed receptors was used as a screening process to identify which exhaust sources could produce potential reingestion problems, requiring further examination through wind tunnel testing. A wind tunnel study was used as an aid to choose the maximally exposed receptors resulting from migration of the chemicals released from the roof vents. Specifically, the wind tunnel study modeled the proposed IAST building and existing surrounding buildings within a two-block radius of the facility in order to determine the impact of exhaust fumes from the fume hoods on ambient air concentrations at nearby locations (RWDI, Inc., 1992). A total of 12 nearby locations representing street level and building level receptors were analyzed in the wind tunnel study.

Simulation of an exhaust plume by the wind tunnel study resulted in measured concentrations at each of the 12 receptor locations. These concentrations were given as the ratio of the source concentration (i.e., IAST laboratory) to the measured ambient concentration and were referred to as dilution factors. Dilution factors represent the reduction in gas concentration as the gas migrates to a receptor due to the effects of atmospheric dispersion and transport. Migration patterns of the gas were determined by the atmospheric dispersion conditions in the area studied. Section 3 discusses the assumptions and methods used to estimate the amount of gas emitted and the dilution factors used to determine the ambient concentrations at potential receptor locations.

2.2.3 Potentially Exposed Populations

This risk evaluation focuses on receptors outside the laboratory environment. A laboratory worker was not considered for evaluation due to the protective measures incorporated in the University Chemical Hygiene Plan, as well as an assumed element of risk which is part

of laboratory operations. Users/occupants within the facility are assumed to respond in accordance with this plan, and thus will not be evaluated.

The initial numerical assessment (computer modeling) did not identify potential exposure concerns in areas in which people reside. Because no one resides within the area selected for detailed assessment in the wind tunnel, a hypothetical "resident" was assumed to be located at the point above street level predicted to have maximum chemical concentrations resulting from IAST emissions. Several potential receptors were considered for evaluation of acute and chronic exposure in this assessment. In addition to possibly evaluating permanent residents for potential acute and carcinogenic effects, residents or patients in any of the medical facilities and students in student housing were considered. The closest medical facility and student resident housing are the Hospital of the University of Pennsylvania located 244 meters southwest of the IAST facility and Hill House located north of Walnut Street approximately 200 meters. Students and faculty were also considered for evaluation of acute exposure as well as street passersby. The potential off-site receptors selected for evaluation were an occasional passerby on the street and in place of an actual local resident, a theoretical individual located at the point of the highest ambient air concentrations predicted by the wind tunnel analysis (i.e., "resident"). Both receptors were evaluated for potential acute toxic effects. In addition, the "resident" also was evaluated for potential carcinogenic risks. The closest residents actually live three blocks north and approximately two blocks west of the facility. However, the exposure modeling was limited to the location points selected for the wind tunnel analysis (approximately a 2 block radius). The point at which the passerby was evaluated is located at ground level on the east side of the IAST facility. The "resident" point is located outside the Duhring Wing of the Fisher Fine Arts Library (across 34th Street in the Furness Building), near roof level. Although evaluation points were limited in the wind tunnel analysis, the data produced from the analysis resulted in more realistic exposure concentrations than a computer model would have. A computer model uses input data and assumptions to derive predicted air concentrations, whereas the wind tunnel data are based on actual measured values.

2.2.3.1 Acute Exposure - Street Passerby

An acute exposure is defined as an exposure to a chemical occurring for a short period of time (less than 24 hours) (Klaassen, et al., 1986). A street passerby was evaluated for potential acute exposure to accidentally released chemicals from the IAST facility. The passerby would be the most probable maximally exposed individual in the general public, other than a resident. Points of potential maximum exposure at the street level on the perimeter of the IAST building were identified during the wind tunnel analysis. The results of this analysis were used as a basis to select a location where a street passerby would receive the maximum exposure.

The maximum exposure concentrations predicted for street level were approximately 2 times less than the above street level concentrations (see Section 3). Although higher chemical concentrations may occur above street level on rooftops or at the sides of buildings, individuals (e.g., window washers and other maintenance personnel) are less likely to be at these locations on a regular basis. An individual located inside an adjacent building, where there may be high chemical concentrations outside the building, was also eliminated as the most probable maximally exposed individual. After dilution and dispersion of the substance by the heating and cooling system inside the building, the risks of exposure to high concentrations inside the building are expected to be minimized (e.g., lower than that of the passerby).

2.2.3.2 Acute and Long-Term/Multiple Release Exposure - "Resident"

Due to the possibility of multiple accidental releases occurring over an extended period, and the lack of an actual resident in the area selected for detailed assessment in the wind tunnel study (2 block radius), excess lifetime cancer risk was evaluated for a hypothetical resident. The initial numerical assessment (computer modeling) did not identify potential exposure concerns in areas in which people reside. Because no one resides within the area selected for detailed assessment in the wind tunnel, a hypothetical "resident" was assumed to be

located at the point above street level predicted to have the maximum chemical concentrations resulting from IAST emissions. This point was identified, based on the analysis, to be located across 34th Street, at the roof level of Duhring Wing of the Fisher Fine Arts building. Although no one currently lives at this point, there may be other long-term occupants (e.g., faculty, other workers) who could be exposed to multiple releases over time. This exposure scenario is highly conservative because the maximum modeled exposure concentrations are estimated for outside the building and at a higher level (e.g. the roof). A person inside a building would be exposed to much lower concentrations due to dispersion and dilution through the air conditioning and heating systems.

In addition to looking at long-term exposure, potential acute exposure was evaluated for the "resident" as well. The results of the wind tunnel analysis showed that the "resident" is the receptor which is located at the point of maximum modeled exposure concentrations. The maximum modeled exposure conditions are predicted for wind conditions that exist about 1% of the year.

SECTION 3
AIR EMISSION AND DISPERSION MODELING

The air quality impact analysis for the proposed IAST building included an emission estimation and a dispersion modeling analysis to determine worst-case ambient concentrations for two locations surrounding the proposed IAST building. The worst-case concentrations were used to determine the risk to potential receptors from exposure to IAST facility emissions. The emission estimation and dispersion modeling analysis are described in the following subsections.

3.1 EMISSION ESTIMATION

The amount of material which could be released to the atmosphere through the fume hoods and roof vents of the IAST facility was estimated for ten compounds identified as compounds most likely to pose an acute and/or chronic health hazard in the event of an accident. The typical amounts (volume or mass) of these compounds used in the IAST facility as shown in Table 3-1, were assumed to be spilled in the laboratory, allowed to evaporate for a 15-minute period and the evaporated mass was assumed to be taken up by the fume hood and released through the roof vents to the atmosphere. The amount of material which would evaporate was calculated using the Areal Locations of Hazardous Atmospheres (ALOHA) model version 5.0 (NOAA, 1992). The concentration of each compound in the stack was based on the amount of material released and the volumetric flow of the fume hood and roof vents. The stack gas concentration for each compound was then used with the results of the wind tunnel analysis of the IAST building to determine the worst-case street level and "resident ambient" concentrations as discussed further in Subsection 3.2.

TABLE 3-1

UNIVERSITY OF PENNSYLVANIA IAST BUILDING EIS

PREDICTED AIR QUALITY LEVELS

COMPOUND	STATE	VOLUME OR MASS	RELEASE AMOUNT (kg)	STACK GAS VOLUME (m^3)	STACK GAS CONCENTRATION (g/m^3)	1-HR STREET AMBIENT CONCENTRATION (ug/m^3)	1-HR "RESIDENT" AMBIENT CONCENTRATION (ug/m^3)
Acrylonitrile	Liquid	8 lbs	0.794	1529	0.52	51.93	112.55
Bromine	Liquid	8.2 lbs	3.72	1529	2.43	243.30	527.30
Chloroform	Liquid	26.5 lbs	3.03	1529	1.98	198.17	429.49
Hexane	Liquid	10 gal	2.17	1529	1.42	141.92	307.59
Hydrazine	Liquid	4.4 lbs	0.0792	1529	0.05	5.18	11.23
Hydrocyanic Acid	Liquid	1 lbs	0.0669	1529	0.04	4.38	9.48
Hydrofluoric Acid	Liquid	1 liter	0.955	1529	0.62	62.46	135.37
Hydrogen Chloride	Gas	34 lbs	15.4	1529	10.07	1007.19	2182.91
Phosgene	Liquid	2.1 lbs	0.953	1529	0.62	62.33	135.09
Trichloroethylene	Liquid	1 qt	1.39	1529	0.91	90.91	197.03

BASIS:

ALOHA Emission Rate Estimates

Dilution Factor 10,000:1 Street and 4,614:1 Resident

3.2 DISPERSION MODELING

The air quality dispersion modeling for roof vent emissions of the IAST building was based on the results of the wind tunnel analysis performed by RWDI, Inc. (RWDI,1992). The wind tunnel analysis determined short-term (i.e. 1-hour) dilution factors for the fume hood vents of the IAST facility and surrounding receptor locations for 24 wind directions and various wind speed conditions expected in the Philadelphia area. The dilution factor represents the reduction of the stack gas concentration due to atmospheric dispersion and transport of a compound from the stack to a receptor location. The minimum dilution factor for the fume hood vent for a street level passerby determined by the analysis was 10,000:1. The smallest dilution factor would produce the highest ambient concentration. The wind tunnel analysis did not determine a dilution factor for any existing resident location. To simulate a residential exposure, the lowest dilution factor for an above street location was used. The lowest dilution factor for the above street location was 4,614:1. Based on the stack concentrations of each chemical and these dilution factors, 1-hr chemical concentrations were determined for each chemical of concern for the two receptor locations. The ambient concentrations for the two receptor locations are presented in Table 3-1.

SECTION 4
EVALUATION OF POTENTIAL HUMAN HEALTH IMPACTS

4.1 TOXICITY ASSESSMENT

The toxicity assessment focuses on the potential acute toxic effects (toxic effects due to short-term exposure) and long-term (carcinogenic) effects. Long-term noncarcinogenic health effects were not considered because occasional accidental releases from the proposed IAST facility are not consistent with the pattern of exposures that would result in chronic adverse health effects.

Health-related air levels which can be used to put the exposure concentrations into perspective were used as the basis for comparison. In general, dose-response data on humans are limited or not available for most chemicals. Information regarding acute health effects in humans usually consists of data from accidents, where the exposure concentrations usually are not known. In some instances data are available from studies on human volunteers where the maximum exposure concentrations are controlled and restricted. Limited human data exists for carcinogenic studies as well, and often animal studies are used to assess a chemical's potential to cause cancer or carcinogenic potential.

A summary of occupational exposure limits (OELs) is provided in Table 4-1. The OELs include those recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) (ACGIH, 1991), the Occupational Safety and Health Administration (OSHA) (BNA, 1992), and the National Institute for Occupational Safety and Health (NIOSH) (CDC, 1988). Among the OELs for each chemical are limits for 10 to 60-minute exposures, concentrations which should not be exceeded at any time (i.e., ACGIH and OSHA ceilings), and/or 8-hour threshold limit value time weighted averages (TLV-TWA). The 8-hour TLV-TWAs are not true short-term exposure limits, because they represent average concentrations that workers may be exposed to for five days per week over a working lifetime. The OELs are intended to protect average healthy workers and not the

Table 4-1
Summary of Occupational Exposure Limits

	ACGIH TLVs mg/m^3(ppm)			OSHA PELs mg/m^3(ppm)			NIOSH RELs mg/m^3(ppm)	
	TWA (8 hrs)	STEL (15 min)	Ceiling	TWA (8 hrs)	STEL (15 min)	Ceiling	TWA (8 hrs)	Ceiling
Acrylonitrile	4.3 (2)	- (-)	- (-)	8.68 (2)	- (-)	21.70 (10)	2.17 (1)	21.70 (10) (15 min)
Bromine	0.66 (.1)	2 (.3)	- (-)	.7 (.1)	2 (0.3)	- (-)	- (-)	- (-)
Chloroform	49 (10)	- (-)	- (-)	9.78 (2)	- (-)	240 (50)	- (-)	9.78 (2) (60 min)
n-Hexane	176 (50)	- (-)	- (-)	180 (50)	- (-)	- (-)	1800 (500)	- (-)
Hydrazine	0.13 (0.1)	- (-)	- (-)	.1 (.1)	- (-)	- (-)	- (-)	0.04 (0.03) (120 min)
Hydrocyanic Acid	- (-)	- (-)	11 (10)	- (-)	5 (4.7)	- (-)	- (-)	5 mg CN/m^3 (4.7) (10 min)
Hydrofluoric Acid	- (-)	-(-)	2.6 mg F/m^3 (3)	2.6 mg F/m^3 (3)	5.0 mgF/m^3 (6)	- (-)	2.5 mg F/m^3 (3)	5.0 mg F/m^3 (6) (15 min)
Hydrogen Chloride	- (-)	- (-)	7.5 (5)	- (-)	- (-)	7 (5)	- (-)	- (-)
Phosgene	0.40 (0.1)	- (-)	- (-)	0.4 (0.1)	- (-)	- (-)	0.4 (0.1)	0.8 (0.2) (15 min)
Trichloroethylene	269 (50)	1,070 (200)	- (-)	270 (50)	1,080 (200)	- (-)	134 (25)	- (-)

Key

Ceiling - ACGIH and OSHA: This concentration should not be exceeded during any part of the working exposure; NIOSH: Based on time intervals.

PEL - Permissible Exposure Limit.

REL - Recommended Exposure Limit.

STEL - Short-term exposure limit; a 15 minute TWA which should not be exceeded any time during the work day. ACGIH states that it is not an independednt exposure limit, but supplements the TWA where there are recognized acute effects from a substance whose toxic effects are primarily chronic in nature. The STEL should not be longer than 15 min. and should not occur more than 4 times per day. There should be at least 60 minutes between successive exposure in this range.

TLV - Threshold Limit Value.

TWA - Time weighted average.

general population, which may contain more sensitive subpopulations (e.g., children, the elderly, and infirm individuals).

To assess potential cancer risk from repeated accidental exposures over a lifetime, an inhalation cancer slope factor was obtained for the carcinogenic compounds evaluated (e.g., acrilonitrile, chloroform, hydrazine, and trichloroethylene). The slope factor converts an estimated daily intake averaged over a lifetime of exposure to an incremental risk of an individual developing cancer. In developing cancer slope factors, the Environmental Protection Agency (EPA) assumes that no threshold for cancer development exists and that the risk of cancer is linearly related to dose (i.e., high dose studies can be extrapolated linearly to extremely small doses, with some risk of cancer remaining even at very low exposure concentrations). For those chemicals with EPA-derived inhalation unit risk factors, slope factors were obtained by assuming an inhalation rate of 20 m^3/day and a body weight of 70 kg (EPA, 1992).

4.2 HEALTH RISK CHARACTERIZATION

The health risk characterization evaluates the potential human health impacts that could result from the hypothetical release and migration scenarios that were described in the exposure scenario section. The evaluation was made assuming that an accidental release occurs separately for each chemical.

In order to evaluate potential noncarcinogenic health risks, the estimated ambient one-hour concentrations for each chemical of concern (Table 3-1) were compared to human (or animal if only limited data exist) toxicity data described in the attachment. In addition to the toxicity data, the occupational exposure limits (OELs) summarized in Table 4-1 were also considered in evaluating potential risk. OELs are intended to protect the average healthy worker and not the general population. However, in the absence of other toxicity data, OELs also were used in this evaluation to gain some perspective as to whether the concentrations predicted would result in nonlethal toxic effects to the general population.

In the following subsections, potential acute exposure levels are evaluated for each of 10 chemicals of concern.

Based on evaluation of the data obtained, an accidental release of any of the chosen chemicals of concern would not pose an acute health threat to either a street passerby or a "resident". The ambient concentrations predicted to be present for an acute exposure to occur results in neither lethality nor any of the toxic effects observed for the compounds. Table 4-2 compares these predicted concentrations to the ACGIH 8-hour TLV-TWA levels for each compound to illustrate that the anticipated one-hour acute concentrations are well below regulated 8-hour occupational exposure levels.

In addition to the evaluation of potential noncarcinogenic risks, the chemicals classified as carcinogens also were evaluated to determine the number of repeated accidental releases which would result in an estimated one-in-one-million (1.00E-06) excess lifetime cancer risk as a result of exposure. In general, 1.00E-06 is a conservative value that has been used by regulatory agencies to set clean-up goals at hazardous waste sites. To determine approximately how many exposures are necessary to result in a 1.00E-06 cancer risk, an ambient air concentration resulting in 1.00E-06 cancer risk was calculated for each chemical and divided by the predicted ambient concentration (Table 4-3). These calculations were based on the assumption that a 70 kg adult (EPA 1989a) inhales a chemical in the ambient air for one hour per accidental chemical release. An inhalation rate of 2.5 m^3/hour was assumed, based on a moderate activity level for an adult male (EPA, 1989b). The receptor was assumed to be exposed to the released chemical for one hour before it dissipates. An averaging time of 25,550 days (i.e., 70 years x 365 days/yr) is used to prorate the dose over a lifetime, in accordance with EPA guidance. This approach for carcinogens is based on the assumption that a high dose received over a short time period is equivalent to a corresponding low dose spread out over a lifetime (EPA, 1989a).

The following subsections summarize the results of this evaluation by chemical. Acute human lowest-observed-effect-levels (LOEL), lowest-observed-lethal-concentrations (LC_{LO}),

TABLE 4-2

PREDICTED CONCENTRATIONS OF CHEMICALS COMPARED TO ACGIH 8-HOUR TLV-TWAs (mg/m^3)

Chemical	Predicted Levels (mg/m^3)		ACGIH 8-Hour TLV-TWAs (mg/m^3)
	Passerby	"Resident"	
Acrylonitrile	0.052	0.113	4.3
Bromine	0.243	0.527	0.66
Chloroform	0.198	0.429	49
Hexane	0.142	0.308	176
Hydrazine	0.005	0.011	0.13
Hydrocyanic Acid	0.004	0.009	– [a]
Hydrofluoric Acid	0.062	0.135	– [a]
Hydrogen Chloride	1.010	2.180	– [a]
Phosgene	0.062	0.135	0.4
Trichloroethylene	0.091	0.197	269

[a] 8-hour TLV-TWAs have not been developed for this chemical

TABLE 4–3

CALCULATION OF THE NUMBER OF
ACCIDENTAL RELEASES OF A CARCINOGEN [a]
NECESSARY TO REACH 1 IN A MILLION CANCER RISK

Equation 1 :

$$\text{Lifetime Cancer Risk}^{b} = \frac{CA \times CF \times IR \times ET \times CSF_{inh}}{BW \times AT}$$

Where :

CA	=	Chemical Concentration in Air (ug/m^3)	=	1 ug/m^3
CF	=	Conversion Factor (mg/ug)	=	0.001 mg/ug
IR	=	Inhalation Rate (m^3/hour)	=	2.5 m^3/hour (EPA, 1989b)
ET	=	Exposure Time (hours)	=	1 hour
CSF_{inh}	=	Inhalation Cancer Slope Factor $(mg/kg/day)^{-1}$	=	Chemical Specific
BW	=	Adult Body Weight (kg)	=	70 kg (EPA, 1989a)
AT	=	Averaging Time – period of exposure	=	25,550 days

Equation 2 :

$$\begin{array}{c}\text{1.00E–06}\\ \text{Risk–Based}\\ \text{Concentration}\end{array} = \frac{\text{1.00E–06}}{\text{Lifetime Cancer Risk}}$$

Equation 3 :

$$\begin{array}{l}\text{Number of Accidental Releases}\\ \text{(Chemical Specific)}\end{array} = \frac{\text{1.00E–06 Risk–Based Concentration}}{\text{Predicted Ambient Concentration}^{c}}$$

[a] Calculated only for compounds evaluated for long–term exposure (carcinogenic).
[b] Reference: EPA, 1989a. Based on one accidental release of one unit of the chemical of concern.
[c] The "resident" 1–hour concentration was used (Table 3–1).

or no-observed-effect-levels (NOEL) were used in the evaluation when available. However, in some cases where human data are limited (i.e., duration of exposure is inadequate or not documented, or effects are not reported for lower concentrations), animal data were used to compare to the modeling results. The discussion focuses on the lowest concentrations at which effects were observed, or the highest concentrations below which no effects were observed. In addition, OELs were also used to put the results in perspective. The modeled ambient air concentrations do not exceed any of the OELs or values presented in the toxicity profiles for any chemical.

4.2.1 Acrylonitrile

Acute Risks

The predicted ambient air concentrations for acrylonitrile are 0.052 mg/m^3 for a passerby and 0.113 mg/m^3 for a "resident". Both of these values are considerably lower than a 45 minute LOEL for multiple symptoms of 35 mg/m^3 and an 8-hour NOEL for neurotoxicity of 10 mg/m^3 reported for humans (ATSDR, 1989). The modeled concentrations also fell below a minimum risk level of 0.33 mg/m^3 for exposures of 14 days or less, calculated based on the 10 mg/m^3 NOEL, adjusting for intermittent exposure. The predicted concentrations also fell below the 8-hour TLV-TWA of 4.3 mg/m^3 by at least two orders or magnitude. These data indicate that neither lethal nor toxic effects are expected to occur after a potential acute exposure to acrylonitrile.

Long-Term Risks

Acrylonitrile has been reported to be a probable carcinogen based on studies in which exposure to workers has been linked to cases of lung cancer. A predicted concentration for a "resident" exposed to the substance is 0.113 mg/m^3. Approximately 27 accidental release episodes would have to occur at the IAST facility in order for acrylonitrile to pose a one-in-one-million cancer risk.

4.2.2 Bromine

Acute Risks

A one hour acute air concentration of 0.243 mg/m^3 was predicted for a passerby and 0.527 mg/m^3 for a "resident". These concentrations fall below the ACGIH TLV-TWA of 0.66 mg/m^3. In addition, the modeled values are approximately four to eight times lower than the 15-minute STEL of 2 mg/m^3, and approximately 50 to 100 times lower than a maximum allowable concentration of 26 mg/m^3 reported in one study based on exposure of one-half to one hour (Clayton and Clayton, 1981). Based on these data, no acute toxic effects are expected to result from an accidental release of bromine from the IAST facility.

Long-Term Risks

Long-term risks were not evaluated for this compound because it is not categorized as a carcinogen.

4.2.3 Chloroform

Acute Risks

The predicted ambient air concentrations for chloroform are 0.198 mg/m^3 for a passerby and 0.429 mg/m^3 for a "resident". These numbers are well below the NIOSH 60-minute ceiling and the OSHA 8-hour TWA of 9.78 mg/m^3, and the ACGIH eight-hour TWA of 49 mg/m^3. One study reported a 4-hour rat NOEL concentration of 371 mg/m^3 and a LOEL of 747 mg/m^3 for hepatic effects (ATSDR, 1991). Another rat study evaluating one hour exposures over eight days reported a lower LOEL of 20.1 mg/m^3 based on fetotoxic effects. The predicted air concentrations are below all of these values, and thus it is expected that acute exposure to chloroform based on an accidental release at the IAST facility would not result in adverse acute health effects.

Long-Term Risks

Studies in mice and rats indicate that chloroform is a carcinogen by the oral route. No available studies have associated chloroform with cancer in humans or animals by the inhalation route. However, EPA has derived an inhalation unit risk factor based on animal data showing an increased incidence of liver carcinoma in mice. In order for chloroform to pose a one-in-one-million cancer risk to the "resident", two accidental releases of chloroform would have to occur in one's lifetime.

4.2.4 Hexane

Acute Risks

The predicted ambient air concentrations for hexane are 0.142 mg/m^3 and 0.308 mg/m^3 for the passerby and "resident," respectively. These predicted concentrations are below all of the available toxicity concentrations by several orders of magnitude. A 15 minute exposure to humans at 3,102 mg/m^3 has been reported to cause eye and upper respiratory tract irritation (Clayton and Clayton, 1981). Other short-term exposures (durations not specified) at levels between 4,935 mg/m^3 and 5,287 mg/m^3 were reported to cause slight nausea, in addition to the symptoms described above. Based on these concentrations and the ACGIH 8-hour TLV-TWA of 176 mg/m^3, a passerby or "resident" is not expected to experience any acute toxic effects after an accidental release of hexane from the IAST facility.

Long-Term Risks

Long-term risks were not evaluated for this compound since it is not categorized as a carcinogen.

4.2.5 Hydrazine

Acute Risks

The ambient air concentration of hydrazine predicted for the passerby is 0.005 mg/m^3 and for the "resident" is 0.011 mg/m^3. Both of these concentrations are below (i.e., by at least

a factor of 10) the available documented concentrations reported to cause toxic effects. The lowest reported LOEL is 0.33 mg/m^3 and is based on a study in which rats were continuously exposed over six months. At this concentration, a decrease in body weight was observed (ACGIH, 1986). The 8-hour ACGIH and OSHA TLV-TWA are 0.13 mg/m^3 and the NIOSH ceiling level for 120 minutes is 0.04 mg/m^3. Although the OELs and LOEL are for periods extending over one hour, this information suggest that no adverse acute effects would occur at the predicted ambient concentrations for the two receptors.

Long-Term Risks

EPA has classified hydrazine as a probable human carcinogen by the inhalation route. Inhalation studies show that nasal tumors develop in rats and mice exposed to 0.07 mg/m^3 of hydrazine. The predicted residential ambient air concentration of 0.011 mg/m^3 falls below this concentration. In order for hydrazine to pose a one-in-one-million cancer risk, four accidental releases of hydrazine would have to occur in a lifetime.

4.2.6 Hydrogen Cyanide

Acute Risks

The predicted ambient air concentrations of hydrogen cyanide for the passerby and "resident" are estimated to be 0.004 mg/m^3 and 0.009 mg/m^3, respectively, should an accidental release at the IAST facility occur. The predicted air concentrations are below all reported acute toxic levels. Exposures to hydrogen cyanide air concentrations of 121 mg/m^3 to 149 mg/m^3 for 30 minutes to one hour may be fatal or dangerous to life. At lower levels (i.e., 50 mg/m^3 to 60 mg/m^3) hydrogen cyanide can be tolerated without effects. Exposure to 20 mg/m^3 to 40 mg/m^3 for several hours may induce only slight symptoms (Clayton and Clayton, 1981). The ACGIH ceiling level has been set at 11 mg/m^3. The predicted air concentration fall below all of these levels by approximately two to five orders of magnitude. Based on this information, acute toxic effects are not expected to occur at the predicted concentrations. In addition, these predicted concentrations fall below the odor threshold of 0.9 mg/m^3 (Ruth, 1986).

Long-Term Risks

Long-term risks were not evaluated for this compound because it is not categorized as a carcinogen.

4.2.7 <u>Hydrogen Chloride</u>

Acute Risks

The predicted ambient air concentrations for hydrogen chloride are 1.01 mg/m^3 for a passerby and 2.18 mg/m^3 for a "resident". Hydrogen chloride has an odor threshold reported to range between 0.38 mg/m^3 to 14.98 mg/m^3 (AIHA, 1989), and most people are able to detect its odor at 1 mg/m^3 to 7 mg/m^3 (NRC, 1987). Hydrogen chloride is immediately irritating at concentrations of 7 mg/m^3 (also the ACGIH and OSHA ceiling level) and greater. Traumatic acute exposures usually occur when escape from exposure is prevented. Irritation of the throat is caused at short exposure to 52 mg/m^3 of hydrogen chloride, and one hour exposures to 75 to 149 mg/m^3 are tolerable. At concentrations of 1,491 mg/m^3 to 2,982 mg/m^3 exposure to hydrogen chloride can be dangerous even for brief exposures (IRIS, 1992). Based on the reported data for hydrogen chloride, receptors may detect its odor at the time of exposure but suffer no adverse acute health effects.

Long-Term Risks

Long-term risks were not evaluated for this compound because it is not categorized as a carcinogen.

4.2.8 <u>Hydrogen Fluoride</u>

Acute Risks

The predicted ambient air concentrations for hydrogen fluoride are 0.062 mg/m^3 and 0.135 mg/m^3 for the passerby and "resident," respectively. These concentrations are below the recommended OELs and the available reported acute toxicity concentrations; however, they are above the odor threshold of 0.03 mg/m^3 (AIHA, 1989). Studies have reported a one

minute human LOEL of 100 mg/m^3 (Clayton and Clayton, 1981) and 30 minute LC_{Lo} of 41 mg/m^3(RTECS, 1992). Exposure to 50 mg/m^3 produced mucous membrane irritation, although a three minute exposure to 26 mg/m^3 resulted in less irritation. The 15-minute NIOSH and OSHA STEL ceilings are reported at 5.0 mg/m^3 (5.3 mg/m^3) and ACGIH and OSHA 8-hour TWA at 2.6 mg/m^3 (2.7 mg/m^3). Exposure to a potential release of hydrogen fluoride at the IAST facility would not cause adverse acute health effects, but based on the odor detection level may be detected by either of the two receptors at time of exposure.

Long-Term Risks

Long-term risks were not evaluated for this compound because it is not categorized as a carcinogen.

4.2.9 Phosgene

Acute Risks

The predicted ambient air concentrations are estimated to be 0.062 mg/m^3 and 0.135 mg/m^3 for a passerby and "resident," respectively. These predicted air concentrations fall below all reported acute toxic levels as well as the odor threshold which is reported to range from 0.5 mg/m^3 to 23 mg/m^3 (AIHA, 1989). Studies have reported pathological changes in lungs of rats after two hour exposures to concentrations as low as 2 mg/m^3 (ACGIH, 1986). According to one study, the maximum concentration of phosgene for prolonged exposure is 4 mg/m^3, 5 mg/m^3 to 10 mg/m^3 is considered dangerous to life for prolonged exposure, 20 mg/m^3 to 40 mg/m^3 is irritating to the eyes and/or respiratory tract within one minute, and 50 mg/m^3 is dangerous to life in 30 to 60 minutes (Clayton and Clayton, 1981). The ACGIH OSHA and NIOSH 8-hour TWA is 0.4 mg/m^3. Since the predicted air concentrations fall below these acute toxic levels and OELs, no adverse acute health effects are expected if phosgene were to be accidentally released from the IAST facility.

Long-Term Risks

Long-term risks were not evaluated for this compound because it is not categorized as a carcinogen.

4.2.10 Trichloroethylene

Acute Risks

The predicted ambient air concentrations for trichloroethylene are 0.091 mg/m^3 and 0.197 mg/m^3 for the passerby and "resident," respectively. Both of these values fall below the acute toxicity values reported for trichoroethylene by at least three orders of magnitude and are well below the ACGIH 8-hour TLV-TWA of 269 mg/m^3. One study reported a human LOEL of 860 mg/m^3 for symptoms of drowsiness, hallucination, and distorted perception, based on an 83-minute exposure (ATSDR, 1991b). A human LOEL for drowsiness of 145 mg/m^3 was reported based on a four hour exposure. The lowest OEL is reported for NIOSH 8-hour TWA of 134 mg/m^3. Based on these toxicity values and OELs, no adverse acute health effects are expected to occur after exposure to trichloroethylene released accidentally from the IAST facility.

Long-Term Risks

As described in the toxicity profile for trichloroethylene provided in the attachment, no studies are available which have provided good evidence that trichloroethylene is linked to an increased cancer risk in humans. Although some uncertainties exist as to trichloroethylene's carcinogenicity, EPA has derived an inhalation cancer scope factor of 1.7E-02 $(mg/kg\text{-}day)^{-1}$. In order for trichloroethylene to pose a one-in-one-million cancer risk, approximately 214 accidental releases of trichloroethylene would need to occur.

SECTION 5
SUMMARY AND CONCLUSIONS

An exposure assessment was performed to evaluate the potential general public exposure levels to chemicals released accidentally from the IAST facility proposed to be built at the University of Pennsylvania. Ten chemicals of concern were considered in the analysis. Information and data provided by the University of Pennsylvania were used to define the worst probable accidental release scenario.

The release scenario evaluated represented an accidental release (e.g. spill) of a chemical which was assumed to be emitted to the environment outside the laboratory via the fume hood. A very conservative approach was used to evaluate the magnitude and extent of the ambient air exposure levels for the chemical under consideration. The ambient air concentrations were estimated based on data from a wind tunnel analysis conducted for a two block radius around the IAST facility. The receptors chosen for the analysis were representative of sensitive locations, such as air intakes on nearby surrounding building, and pedestrian areas. In the exposure assessment, the maximum ground (street) level and above-street level receptors were chosen to represent the two populations to be at potential health risk should an accidental spill occur. The ground level receptor was assumed to be a passerby, and the above-street level receptor was assumed to be a hypothetical resident. The actual residential populations in the vicinity are located outside the 2-block radius studied, thus, exposure was evaluated for a hypothetical resident located at the maximum predicted concentration for an above-ground receptor point.

The passerby was evaluated for acute exposure and the hypothetical "resident" was evaluated for acute and long term exposures to potential chemical releases. Types of acute effects that were evaluated included, for example, eye and skin irritation, organ toxicity, and lethality. In addition, for the "resident" an evaluation was made to determine the number of accidental releases of a carcinogen, at the maximum modeled exposure concentrations, which would result in a lifetime excess cancer risk of one-in-one-million or greater.

The results of this assessment have suggested that in the event of an accidental release of any one compound in the IAST facility, the nearby population would not be at risk of exposure to acute toxic or lethal exposure concentrations. Also, it was demonstrated that a cancer risk level of one-in-one-million would not result in the event of one accidental release of a carcinogen in a lifetime. It was estimated that 27 accidental releases were necessary for acrylonitrile, 2 for chloroform, 4 for hydrazine, and 214 for trichloroethene, to reach a one-in-one-million excess lifetime cancer risk.

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APPENDIX F

F.1 INTRODUCTION

F.1.1 Definitions

Noise is unwanted sound. In general, there are three primary sources of noise in the study area: motor vehicle noise (automobiles, trucks, and buses), industrial noise (HVAC systems), and community ambient noise (pedestrians). In addition, others sources of noise that exist at the proposed site that cannot be readily grouped in the aforementioned categories are sirens from emergency vehicles, trains, helicopters, airplanes, construction at other locations etc.

Sound is measured in many ways but the most common measure is a calculation of the sound pressure level. Sound has different frequency characteristics and these must be accounted for in measuring the sound pressure level. Modern noise dosimeters measure sound pressure levels with different frequencies and mathematically combine these readings to create a composite noise level. Each of these frequencies are also weighted in proportion to their sensitivity to the human ear. The "A" scale is the weighting scale most widely accepted because it most accurately corresponds with the response of the human ear. Therefore, the "A" scale was used in these analyses. Again, modern noise dosimeters have these adjustment factors built into them. The unit of measure typically used on the A scale is the decibel (dBA).

All weighting scales are logarithmic. Therefore, two noise sources cannot be linearly added together to obtain the total noise level. For example, two 74 dBA noises occurring at the same distance from the receiver and over the same medium have a composite unadjusted noise level of 77 dBA as calculated by Equation F.1.

$$L=10\log_{10}\sum_{i=1}^{n}10^{L_i/10} \qquad \text{(F.1)}$$

where L_i = A weighted sound level measured in dB

To be able to analyze the cumulative effect of noise levels, the concept of composite noise level was developed. The total overall noise level is determined by the logarithmic addition of all individual noise levels over the time period studied. This calculation determines the equivalent noise level, L_{eq}, and is calculated according to Equation F.2.

$$L_{eq}=10\log_{10}\left[\frac{1}{n}\sum_{i=1}^{n}10^{L_i/10}\right] \qquad \text{(F.2)}$$

The amount of noise measured at any point is a function of many factors.[1] Noise carries further over a hard surface such as a parking lot than over a soft surface such as a grass area. The distance between the noise source and the receiver is important as noise decreases by about 4.5 dBA for each doubling of the distance between

[1] Fundamentals of Traffic Engineering, 10th Edition, Chapter 31, Highway Traffic Noise, Wolfgang S. Homburger and James H. Kell, 1981.

the source and the receiver over soft surfaces. Noise screens including artificial solid screens, buildings or berms separating noise sources from the receiver decrease noise. Any solid screen can serve as a noise barrier. A wall or building can serve as such a barrier to sound and provide some noise reduction.[2]

Another question that frequently occurs is what represents a significant change in noise levels. A change of 3 dBA is not likely to be perceptible but a change of 5 dBA will be. A change of 10 dBA will appear to be twice as great as an increase of 5 dBA but an increase of 20 dBA will not be twice as great as a 10 dBA increase due to the logarithmic effect[3]. Table F-1 is provided to illustrate comparative noise values in relation to common experience.

F.1.2 METHODOLOGY

Noise measuring devices have a wide range in accuracy, complexity and price. For the noise measurements conducted for this project, a QUEST M-28 and six QUEST M-15 Noise Logging Dosimeters were used. These models meet the requirements of the American National Standards Institute (ANSI) Standard Specifications S1.4-1983. The battery condition of each noise meter was checked before and after each reading to ensure proper performance. The noise meters were also calibrated for accuracy prior to the noise measurements with the QUEST Sound Level Calibrator. The QUEST Dosimeters sample the noise levels every sixteenth of a second and mathematically determine the L_{eq}.

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[2] Ibid.

[3] Standard Handbook for Civil Engineers, Third Edition, 1983.

TABLE F.1: COMPARATIVE SOUND LEVELS

COMMON OUTDOOR SOUND LEVELS	NOISE LEVEL (dBA)	COMMON INDOOR NOISE LEVELS
	110	Rock Band
Jet Flyover at 1000 ft.		
	100	Inside Subway Train
Gas Lawnmower at 3 ft.		
Diesel Truck at 50 Ft.	90	Food Blender at 3 ft. Garbage Disposal at 3 ft.
Noisy Urban Daytime		
	80	Shouting at 3 ft.
Gas Lawnmower at 100Ft.		Vacuum Cleaner at 10 ft.
	70	Normal Speech at 3 ft.
Commercial Area Heavy Traffic at 300 Ft.		
	60	Large Business Office
		Dishwasher Next Room
	50	Small Theater, Large Conf. Room (Background)
Quiet Urban Nighttime		
	40	
Quiet Suburban Nighttime		Library
	30	Bedroom at Night Concert Hall (Background)
Quiet Rural Nighttime		
	20	Broadcast and Recording Studio
	10	Threshold of Hearing
	0	

Source: Acentech 1990

F.2 EXISTING AMBIENT NOISE LEVELS

F.2.1 Introduction

Traffic Planning and Design, Inc. examined the noise impact of the proposed building on the existing ambient noise conditions. Of the several sites originally considered, the following three sites are currently under consideration for locating the proposed facility, and thus the subject of these more detailed investigations:

1. The Proposed Action and Reuse of Smith Hall Alternative at the existing Smith Building on 34th Street, adjacent to the Chemistry building.

2. The Alternative B site at the existing parking lot on the north side of Walnut Street, east of the LRSM building.

3. The Alternative C site on 33rd Street, north of Franklin Field.

The impact at each proposed location was analyzed for two conditions:

- During construction of the building
- After completion of the building

Of the three alternative sites, Smith Hall site could potentially have the most impact. This site is located in the central part of the campus, comprises the largest area (renovation of the two buildings and demolition/construction of a third), and is surrounded by the most buildings. Therefore, eight readings were conducted in the vicinity of Smith Hall and two readings each were conducted for LRSM and Lott.

Noise measurements were conducted with the QUEST Dosimeters at a total of twelve points (1-12) in the study area during the week of September 21-24, 1992 between the following street peak hours:

- 7:00 A.M. and 9:00 A.M.
- 11:00 A.M. and 1:00 P.M.
- 4:00 P.M. and 6:00 P.M.

The locations of the twelve data collection points in the study area are indicated on Figure F-1. The data points selected within the study area represent sensitive receptor locations that may be effected by the projected construction and operation of the IAST.

F.2.2 Existing Ambient L_{eq} Noise Levels

The results of the existing ambient noise measurements are presented in Table F-2. Existing ambient L_{eq} readings at the twelve receptor locations in the study area range from 62.4 to 76.5 dBA. As indicated in this table, ambient noise levels during at least one time period at all receptor points approach or exceed the 66 dBA criteria in Pennsylvania for consideration of abatement measures.

TABLE F-2
EXISTING NOISE MEASUREMENTS
(dBA)

Location	A.M. PEAK HOUR		MIDDAY PEAK HOUR		P.M. PEAK HOUR	
	Event	L_{eq}	Event	L_{eq}	Event	L_{eq}
1	1	72.9	4	72.0	7	73.2
2	2	74.7	5	73.5	8	73.7
3	3	72.9	6	68.9	9	68.0
4	19	70.4	22	65.9	25	64.5
5	20	65.5	23	65.0	26	66.5
6	21	63.2	24	65.7	27	62.4
7	13	76.5	16	70.8	10	67.9
8	14	68.7	17	67.3	11	68.2
9	15	69.7	18	67.8	12	68.2
10	28	71.3	31	67.8	34	68.6
11	29	71.2	32	70.1	35	70.5
12	30	66.4	33	73.1	36	67.6

F.3 PROJECTED NOISE LEVELS

F.3.1 Introduction

The National Environmental Policy Act of 1969 (NEPA) requires that the potential impacts of projects involving Federal funds be identified and studied. One such impact can be an increase in community noise levels. The FHWA interprets the requirements to cover not only the noise impact of a project after construction, but the noise impact of the construction process itself.[4]

The FHWA states in its highway noise regulation that in addition to analyzing the potential impact of a project, the following steps should be taken by the performing agency:[5]

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[4] Bowlby, W., and Cohn, L.F., "Prediction of Highway Construction Noise Levels," Journal of Construction Engineering and Management, Vol. 109, No. 2, June 1983.

[5] "Procedures for Abatement of Highway Traffic Noise and Construction Noise," 23 CFR Part 772, FHWA, April 1988.

A. Identify "receptors" in the community that are sensitive to construction noise.

B. Determine mitigation measures for those receptors impacted by construction noise, weighing cost, and feasibility against benefits.

C. Incorporate the needed abatement measures into plans and specifications for the project.

F.3.2 Projected Construction Conditions

To model noise conditions that exist during the construction phase of the project, the computer model Highway Construction Noise Computer Program (HICNOM), FHWA, March 1990 was used. Information was supplied by SAE Americon, the general contractor for the IAST construction, with regard to the type and use of equipment, the construction schedule, the hours of operation, the number of employees, etc. Based on analyses of the different time periods given on the construction schedule, it was found that the most noise was generated during the one month period between July and August 1994 when the pile driver would be used. Assuming use of the pile driver for six hours out of each eight hour work day and two truck deliveries per day, projected noise conditions that would exist during the construction phase of the project were determined for each alternative site.

Noise at each receptor point due to construction activities alone was modeled. These values were added to ambient conditions for each respective time period when construction may take place (A.M. and Midday peak hours), resulting in the projected L_{eq} values associated with construction at the twelve receptor locations. The results of this modeling are presented in Tables F-3 and F-4. As indicated in Table F-3, L_{eq} noise levels for six of the eight receptors (5, 6, 8, 9, 11, and 12) that would be most impacted at the Smith Hall site would increase by at least 10 dBA during the A.M. peak hour for the construction phase (without mitigation measures) primarily due to the use of pile drivers. An increase of 10-15 dBA represents a substantial noise increase for the Commonwealth of Pennsylvania according to the U.S. Department of Transportation (USDOT) publication Summary of State Highway Agency Noise Policy Definitions, June 1991. None of the receptors would be impacted by the construction at the LRSM site. Both of the receptors that would be most impacted at the Lott Tennis Court site would experience L_{eq} noise level increases in excess of 12 dBA in the midday peak hour.

The USDOT requires that substantial noise increases must be mitigated to produce at least a 5 dBA reduction compared to unmitigated levels. Numerous mitigation measures could be employed to minimize this impact. One such measure would be the construction of a six foot high temporary noise wall (fence) around the perimeter of the site (which could serve the dual purpose of securing the site). A second set of projected conditions was modeled assuming the installation of this fence. Appendix F-3 contains the results of these analyses and identifies the noise levels at each receptor due solely to construction with mitigation. These values added to ambient conditions result in the projected L_{eq} readings with mitigation measures at each receptor given in Tables F-3 and F-4.

As indicated in Tables F-3 and F-4, noise levels at most of the impacted receptor points would be reduced to levels at or near ambient levels if the fence is constructed. However, in 13 of the 24 case identified in Tables F-3 and F-4, unmitigated L_{eq} noise levels would exceed ambient conditions by at least 10 dBA. As required by

Pennsylvania standards, noise reductions of at least 5 dBA from unmitigated projected conditions can be obtained in all cases through installation of a six foot high wall as given in Tables F-3 and F-4. The following measures are additional methods for mitigating construction noise:[6]

A. Community Relations - Establish a good rapport with the community by informing them of any potential construction noise impacts and measures that will be employed to reduce these impacts.

B. Design Considerations - Locating and sequencing construction operations to reduce potential noise impacts at sensitive receptors. This includes locating noisy elements such as compressors and pumps to less sensitive areas on the construction site, use of barriers such as noise fences or material stockpiles, and the consideration of other construction methods (i.e., using cast-in-place piles rather than driven piles, rubber-tired equipment rather than steel-tracked equipment, etc.)

C. Source Control - Use of new construction equipment which is generally quieter than older equipment and the use of effective mufflers.

D. Site Control - Measures to abate construction noise can modify the time, place, or method of operation for a particular noise source. This includes restricting the amount of time each day certain equipment such pile drivers are used as well as hours of construction worked by employees.

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6 "Analysis of Highway Construction Noise," FHWA Technical Advisory T-6160.2, March 13, 1984.

TABLE F-3
RECEPTOR LOCATION MOST IMPACTED IN AM PEAK HOUR BY CONSTRUCTION NOISE FOR EACH ALTERNATIVE SITE (dBA)

RECEPTOR	AMBIENT	PROJECTED NOISE WITH CONSTRUCTION	CHANGE FROM AMBIENT	PROJECTED NOISE WITH CONSTRUCTION W/MITIGATION	CHANGE FROM AMBIENT
SMITH HALL SITE					
5	65.5	77.0	11.5	68.7	3.2
6	63.2	82.7	19.5	71.2	8.0
7	76.5	76.5	0.0	76.5	0.0
8	68.7	78.8	10.1	70.7	2.0
9	69.7	83.8	14.1	73.7	4.0
10	71.3	77.1	5.8	71.8	0.5
11	71.2	82.0	10.8	72.7	1.5
12	66.4	79.6	13.2	69.4	3.0
LRSM SITE					
1	72.9	73.4	0.5	72.9	0.0
2	74.7	74.7	0.0	74.7	0.0
LOTT TENNIS COURT SITE					
3	72.9	81.6	8.7	73.9	1.0
4	70.4	78.6	8.2	71.4	1.0

TABLE F-4
RECEPTOR LOCATION MOST IMPACTED IN MIDDAY PEAK HOUR BY CONSTRUCTION NOISE FOR EACH ALTERNATIVE SITE (dBA)

RECEPTOR	AMBIENT	PROJECTED NOISE WITH CONSTRUCTION	CHANGE FROM AMBIENT	PROJECTED NOISE WITH CONSTRUCTION W/MITIGATION	CHANGE FROM AMBIENT
SMITH HALL SITE					
5	65.0	77.0	12.0	68.2	3.2
6	65.7	82.7	17.0	71.7	6.0
7	70.8	71.3	0.5	70.8	0.0
8	67.3	78.8	11.5	70.3	3.0
9	67.8	83.8	16.0	72.7	4.9
10	67.8	76.6	8.8	68.8	1.0
11	70.1	82.0	11.9	72.1	2.0
12	73.1	80.6	7.5	74.1	1.0
LRSM SITE					
1	72.0	72.5	0.5	72.0	0.0
2	73.5	74.0	0.5	73.5	0.0
LOTT TENNIS COURT SITE					
3	68.9	81.1	12.2	71.4	2.5
4	65.9	78.1	12.2	68.4	2.5

F.3.3 PROJECTED OCCUPANCY CONDITIONS

The existing ambient noise measurements along with the existing traffic volumes were used to calibrate the STAMINA 2.0/OPTIMA Noise Prediction Model (FHWA-DP-58-1), March 1983, to permit a noise modeling simulation of the project site after occupancy (full build-out). In the calibration stage, the variables in the model were determined that would result in L_{eq} projections equal to those measured at each noise monitoring location. Once the values of the variables were established in the calibration phase, the projected traffic volumes were used to model noise conditions after occupancy of the proposed building.

The projected L_{eq} readings modeled for the twelve receptor locations in the study area are presented in Table F-5. When compared to the existing ambient noise readings given in this table, it can be seen that the minimal increase in traffic due to the construction of proposed site would have little to no affect on the background noise levels. In only 5 of the 36 cases would the noise levels increase and even then it is only by 0.1 dBA. As noted in Section F.3.2, this increase would not represent a substantial increase in noise levels per Pennsylvania noise criteria.

Noise levels due to the HVAC equipment as measured at the receptor locations would be minimal and significantly less than the traffic noise. It is recommended that this equipment be enclosed on the sides to further abate any possible noise. As such, the HVAC equipment would not increase noise levels at the receptor points.

TABLE F-5
PROJECTED OCCUPANCY NOISE MEASUREMENTS
(dBA)

Location	A.M. PEAK HOUR Exist.	A.M. PEAK HOUR Proj.	MIDDAY PEAK HOUR Exist.	MIDDAY PEAK HOUR Proj.	P.M. PEAK HOUR Exist.	P.M. PEAK HOUR Proj.
1	72.9	72.9	72.0	72.0	73.2	73.2
2	74.7	74.7	73.5	74.7	73.7	73.7
3	72.9	72.9	68.9	68.9	68.0	68.0
4	70.4	70.4	65.9	65.9	64.5	64.5
5	65.5	**65.6**	65.0	65.0	66.5	66.5
6	63.2	**63.3**	65.7	65.7	62.4	62.4
7	76.5	76.5	70.8	**70.9**	67.9	67.9
8	68.7	68.7	67.3	67.3	68.2	68.2
9	69.7	**69.8**	67.8	67.8	68.2	68.2
10	71.3	71.3	67.8	67.8	68.6	68.6
11	71.2	71.2	70.1	**70.2**	70.5	70.5
12	66.4	66.4	73.1	73.1	67.6	67.6

NOTE: Increased Noise Levels are indicated in bold.

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APPENDIX G

MEMORANDUM OF AGREEMENT
BETWEEN THE UNITED STATES AIR FORCE, THE UNIVERSITY OF PENNSYLVANIA, THE PHILADELPHIA HISTORICAL COMMISSION, THE PENNSYLVANIA HISTORICAL AND MUSEUM COMMISSION AND THE ADVISORY COUNCIL ON HISTORIC PRESERVATION ON THE DEMOLITION OF SMITH HALL AND CONSTRUCTION OF THE INSTITUTE FOR ADVANCED SCIENCE AT THE UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA PA

WHEREAS, the United States Department of the Air Force (Air Force) is administering Federal funding for development of an Institute of Advanced Science and Technology (IAST) by the University of Pennsylvania (University);

WHEREAS, the Air Force has determined that development of the IAST will have an effect upon the University of Pennsylvania Historic District, a property included in the National Register of Historic Places, and the Furness Building, a National Historic Landmark,

WHEREAS, the Air Force has consulted with the Pennsylvania State Historic Preservation Officer (SHPO) and the Advisory Council on Historic Preservation (Council) pursuant to the regulations (36 CFR Part 800) implementing Section 106 and 110 of the National Historic Preservation Act (16 U.S.C. Section 470f),

WHEREAS, the University and the Philadelphia Historical Commission participated in the consultation and have been invited to concur with this Memorandum of Agreement,

NOW, THEREFORE, the Air Force, the Pennsylvania SHPO, and the Council agree that the undertaking shall be implemented in accordance with the following stipulations in order to take into account the effect of the undertaking on historic properties.

STIPULATIONS

The Air Force shall ensure that the following stipulations are carried out:

1. Demolition of Smith Hall shall not take place until all necessary and full funding for Phase I of the IAST has been secured by written, firm and final commitments from all funding sources, and all necessary permits and other approvals for construction have been successfully obtained.

2. Prior to demolition of Smith Hall and construction of Phase I of the IAST, the University shall contact the Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER), of the National Park Service to determine what level and kind of recordation is required for Smith Hall, Smith Walk, the Morgan Building, and the Music Building. Unless

otherwise agreed to by HABS/HAER, the University shall ensure that all documentation is completed and accepted by HABS/HAER prior to demolition of Smith Hall and construction of Phase I of the IAST. Copies of this documentation will be made available to the PHC, the Pennsylvania SHPO, and the University of Pennsylvania Archives.

3. Prior to demolition of Smith Hall, the University will consult with the PHC and the Pennsylvania SHPO to determine if there are architectural elements of the building that could be salvaged for curation or display purposes. Any such items will be removed from the building in a manner that minimizes damage and will be stored by the University for use in conjunction with implementation of the interpretive plan provided for in Stipulation 6.

4. The University shall preserve and maintain the Morgan Building, Music Building, Hayden Hall, the Cret Wing of the Chemistry Laboratory, and the Towne Building while funding is being sought for Phases II, III, and IV of the IAST.

5. Design for Phases II, III, and IV of the IAST shall be developed and coordinated as follows:

   A. Rehabilitation activities shall be consistent with the recommended approaches to rehabilitation set forth in the Secretary of the Interior's Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings (Standards).

   B. New construction behind Morgan and Music Buildings shall be compatible with the historic and architectural qualities of those buildings and the Towne Building in terms of scale, massing, color and materials, and shall be responsive to the recommended approaches to new construction set forth in the Standards.

   C. Designs and specifications for Phases II, III, and IV will be developed in consultation with the PHC and the Pennsylvania SHPO and will be submitted to the PHC and the Pennsylvania SHPO prior to implementation.

6. The University shall develop and implement a plan for interpreting the history and buildings of the Central Science Precinct for students, faculty, and visitors.

   A. The plan shall provide for outdoor interpretive signage for extant buildings and Smith Walk. Previously demolished buildings and Smith Hall shall also be interpreted in this outdoor signage program. The plan shall also provide for an indoor interpretive display in a public space within the precinct.

   B. The plan shall include a timeline for implementation.

C. The interpretive plan shall be developed in consultation with the PHC and will be completed within two years from the date of this Agreement. The University shall forward the plan to the Air Force, the Pennsylvania SHPO, and the Council for review and comment.

7. Within two years of the date of this Agreement, the University shall develop, complete and begin implementation of a Cultural Resources Management Plan (CRMP) for the University.

A. The essential purpose of the CRMP shall be to establish processes for the continuing integration of the preservation and use of historic buildings with the mission and programs of the University.

i. The CRMP shall include descriptions of all properties within the University campus that are known or thought to meet the National Register criteria (36 CFR Section 60.4).

ii. The CRMP shall establish procedures for planning and decisionmaking for the maintenance, management, and use of historic properties on campus.

iii. The CRMP shall establish procedures for integrating consideration of the significance of historic properties into overall campus planning and avoiding or mitigating unavoidable adverse impacts to historic properties.

B. The CRMP will be prepared by or under the supervision of an individual or individuals who meet, at a minimum, the professional qualifications standards for history, archeology, and architectural history in the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation (48 FR 44738-9).

C. The CRMP shall be developed in consultation with the PHC and the Pennsylvania SHPO and the views of the public shall be solicited during the development of the CRMP.

Execution of this Memorandum of Agreement and carrying out its terms evidences that the Air Force has afforded the Council an opportunity to comment on the development of the IAST and its effects on historic properties, and that the Air Force has taken into account the effects of the project on historic properties. If, however, after the execution of this agreement, the Air Force determines not to provide Federal funding for the IAST, the foregoing stipulations will have no force or effect. If, after the execution of this Memorandum of Agreement, Federal funding for the IAST is provided but the IAST is not developed for any reason at its proposed location substantially as

currently designed, the parties of this Memorandum of Agreement will not be bound by the foregoing stipulations but the Air Force will reinitiate consulation with the parties to this agreement pursuant to 36 CFR Part 800.

UNITED STATES DEPARTMENT OF THE AIR FORCE

BY: ______________________________ (date) 12-6-94
Deputy Assistant Secretary of the Air Force
(Environment, Safety and Occupational Health)

PENNSYLVANIA HISTORICAL AND MUSEUM COMMISSION

BY: ______________________________ (date) 1/19/95
Deputy State Historic Preservation Officer

ADVISORY COUNCIL ON HISTORIC PRESERVATION

BY: ______________________________ (date) 2/15/95
Executive Director

CONCUR:

UNIVERSITY OF PENNSYLVANIA

BY: ______________________________ (date) Dec 21, 1994
Provost Stanley Chodorow

PHILADELPHIA HISTORICAL COMMISSION

BY: ______________________________ (date) Dec. 23, 1994
Historic Preservation Officer

APPENDIX H

NPS Form 10-900
(Rev. 8-86)

OMB No. 1024-0018

United States Department of the Interior
National Park Service

National Register of Historic Places Registration Form

This form is for use in nominating or requesting determinations of eligibility for individual properties or districts. See instructions in *Guidelines for Completing National Register Forms* (National Register Bulletin 16). Complete each item by marking "x" in the appropriate box or by entering the requested information. If an item does not apply to the property being documented, enter "N/A" for "not applicable." For functions, styles, materials, and areas of significance, enter only the categories and subcategories listed in the instructions. For additional space use continuation sheets (Form 10-900a). Type all entries.

1. Name of Property

historic name Institute of Hygiene, University of Pennsylvania

other names/site number (Edgar Fahs) Smith Hall

2. Location

street & number 215 South 34th Street ☐ not for publication

city, town Philadelphia ☐ vicinity

state PA code county Philadelphia code 101 zip code 19104

3. Classification

Ownership of Property	Category of Property	Number of Resources within Property		
		Contributing	Noncontributing	
[x] private	[x] building(s)	____	____	buildings
☐ public-local	☐ district	____	____	sites
☐ public-State	☐ site	____	____	structures
☐ public-Federal	☐ structure	____	____	objects
	☐ object	____	____	Total

Name of related multiple property listing:
N/A

Number of contributing resources previously listed in the National Register ____

4. State/Federal Agency Certification

As the designated authority under the National Historic Preservation Act of 1966, as amended, I hereby certify that this ☐ nomination ☐ request for determination of eligibility meets the documentation standards for registering properties in the National Register of Historic Places and meets the procedural and professional requirements set forth in 36 CFR Part 60. In my opinion, the property ☐ meets ☐ does not meet the National Register criteria. ☐ See continuation sheet.

Signature of certifying official Date

State or Federal agency and bureau

In my opinion, the property ☐ meets ☐ does not meet the National Register criteria. ☐ See continuation sheet.

Signature of commenting or other official Date

State or Federal agency and bureau

5. National Park Service Certification

I, hereby, certify that this property is:

☐ entered in the National Register.
☐ See continuation sheet.
☐ determined eligible for the National Register. ☐ See continuation sheet.
☐ determined not eligible for the National Register.
☐ removed from the National Register.
☐ other, (explain:) ____

Signature of the Keeper Date of Action

6. Function or Use

Historic Functions (enter categories from instructions)

Education: Research facility - laboratory
Health Care: Medical Research facility

Current Functions (enter categories from instructions)

Education: College

7. Description

Architectural Classification (enter categories from instructions)

Other: Modern German Classicism

Materials (enter categories from instructions)

foundation Sandstone
walls Brick
Pressed brick
roof Metal
other

Describe present and historic physical appearance.

The Institute of Hygiene (E. F. Smith Hall) is a two story laboratory and classroom building situated at the southeast corner of 34th and Locust Streets (the latter is now a walkway known as Smith Walk) on the campus of the University of Pennsylvania. Constructed between 1890 and 1892, the building is an integral part of an ensemble of late-nineteenth century buildings that formed the core of the University's science precinct at the turn of the century and are the only group of academic buildings on the campus that remain in their original setting, separated by small grass plots and united by a common vocabulary of materials, scale and details.

The Institute of Hygiene was one of the first buildings erected in the precinct, just east of the main college buildings, College Hall and the Furness library. The site was selected for its distance from the Woodland Avenue so that delicate laboratory measurements would not be affected by vibrations from heavy traffic along the street. In plan the building forms an irregular L, consisting of a main facade facing west on 34th Street and a long north wing which extends to the east. The north elevation forms an edge to the pedestrian path of Smith Walk, the south wing abuts a modern chemistry laboratory. Designed as a dedicated research laboratory with classroom space, the building was erected in a synthetic German style that expressed its function and the modernity of the building type.

The main facade on 34th Street consists of two slightly projecting wings which frame a central entrance. Originally the wings were symmetrical, each containing three ranks of windows and capped by a pedimented gable. In 1899, soon after the building was completed, the south wing was replaced by a larger wing which continued the materials and detailing of the original building. Above the sandstone basement, the walls are of red brick accented by courses of stamped terra cotta panels and pressed brick at the floor levels, tops of windows and below the cornice. Windows are headed by dressed sandstone lintels and preserve their original 2/2 double-hung wood sash. Decorative details are limited in keeping with the building's function as a laboratory; only the 34th Street facade is given any ornamental elaboration, consisting of a bold classical entrance portico carried on sandstone pilasters below low a pediment.

The north, south and east elevations continue the articulation of the main facade with a cut stone basement, brick walls and horizontal bands of terra cotta and pressed brick. The unusually large windows were specified as part of the experimental program to provide light and ventilation, as were the mesh-covered intake vents located beneath the windows in the terra cotta courses. Capping the

[x] See continuation sheet

building is a shallow roof with each of the wings expressed by a pedimented gable of extremely low pitch, a characteristic hallmark of nineteenth century German classicism. Here too the experimental laboratory program is visible in the dramatic assemblage of chimneys and ventilators which were part of the innovative system of air circulation.

The plan of the building reflects its design as a laboratory building (see attached plans). Laboratories and research rooms were arranged along a central corridor that extended east in the long north arm of the L. The corridor continued south to the south wing which contained a large open classroom. The staircase is set into the reentrant angle between the north and west wing; it is well-preserved and retains its balusters and newel, with its vigorous turning. Although some ceilings have been dropped and some modern partitions inserted, the original plan and division of rooms is remarkably intact. The original finishes -- plaster walls, wood trim and decorative pressed metal cornices and ceilings -- are also preserved throughout most of the building.

The most extraordinary feature of the building lies in the way in which the experimental systems, including heating and ventilating systems, were integrally incorporated into the program of the building. A variety of types of systems were included to provide data on the relative efficacy of different methods: this is most strikingly seen in the original chemical laboratory, now a seminar room, which was equipped with four separate types of radiators, of different manufacture and configuration. These remain in place and are an exceptional detail for a surviving nineteenth century laboratory building. The building was also outfitted with an innovative convection system of air circulation the machinery and flues of which are also intact (see photograph 12).

The building is in good condition and its historical integrity is remarkable, comprising not only its original structure and plan but also interior finishes and the experimental systems and fixtures that were part of the original program. The 1899 wing, constructed by architects Duhring, Okie and Ziegler, followed so closely on the heels of the original construction and matched it so closely in materials, detail and function, that it can be considered an extension of the original building campaign. A small c.1940 brick addition to the south of the wing detracts little from the overall design. The site also features a small, one-story red brick structure to the rear, detached from the main building, which was used to house laboratory animals.

Finally, the building is an integral component of an ensemble of late-nineteenth and early twentieth century buildings along Smith Walk and 34th Street that comprise the science precinct of the turn of the century campus. The group represents the first major expansion of the University's West Philadelphia campus and together present the suburban ideal of its early planning. This group of buildings in their original setting are the only surviving section of the nineteenth century campus landscape.

8. Statement of Significance

Certifying official has considered the significance of this property in relation to other properties:

[x] nationally [ ] statewide [ ] locally

Applicable National Register Criteria [ ] A [x] B [x] C [x] D

Criteria Considerations (Exceptions) [ ] A [ ] B [ ] C [ ] D [ ] E [ ] F [ ] G

Areas of Significance (enter categories from instructions)

Education
Science
Medicine
Public Health
Social History
Architecture
Engineering

Period of Significance

1892-1970

Significant Dates

Cultural Affiliation

Significant Person

Billings, John Shaw; Pepper, William
Lea, Henry Charles; Mitchell, Silas Weir

Architect/Builder

Collins & Autenrieth - 1892
Duhring, Okie & Ziegler - 1899

State significance of property, and justify criteria, criteria considerations, and areas and periods of significance noted above.

The University of Pennsylvania's Institute of Hygiene, now called Smith Hall, was the first independent university hygiene laboratory in the United States. Adjacent to the main college and library buildings, the Institute is the cornerstone of the university's original science precinct and reflects the intellectual revolution that in the last quarter of the nineteenth century transformed the American college into the modern university and, simultaneously, transformed the nature of scientific and medical education and practice. Designed as a "machine for research", the building was a radical departure from earlier laboratories that merely served as shells for scientific activities. The Institute of Hygiene, which retains the innovative heating and ventilating systems intended to test the ideas generated by researchers working within, is a remarkable document of this new ethos of research. Its development too is notable as the product of an unusually rich collaboration between four of the most prominent figures of the period: John Shaw Billings, the nation's leading public health expert: Henry C. Lea, the internationally noted historian, medical publisher, reformer and philanthropist; S. Weir Mitchell, America's first celebrity psychiatrist, and William Pepper, noted physician and Provost of the University of Pennsylvania. The Institute they produced embodies the strong faith in scientific investigation that characterized late nineteenth-century social reform, and is nationally significant in the history of education, science, medicine, public health, architecture and engineering, and for its association with some of the most pre-eminent intellectual figures of late nineteenth-century America.

The movement to build the Institute of Hygiene at the University began in the mid-1880s as part of Provost William Pepper's campaign to restore the University's medical departments to their former prominence. Philadelphia had been a national center of medical education since colonial times although its pre-eminence began to erode in the 1870s in the face of educational reforms at Harvard Medical School under the leadership of Charles Norton Eliot. Curricular reforms in undergraduate education at Harvard College and the new Johns Hopkins University were also changing the face of higher education and Pepper became determined that Penn would not be left behind. Changes begun under his predecessor Charles Stille's tenure were now pushed forward by Pepper with great speed.[1]

[x] See continuation sheet

9. Major Bibliographical References

See continuation sheet

[x] See continuation sheet

Previous documentation on file (NPS):

- [ ] preliminary determination of individual listing (36 CFR 67) has been requested
- [x] previously listed in the National Register
- [ ] previously determined eligible by the National Register
- [ ] designated a National Historic Landmark
- [ ] recorded by Historic American Buildings Survey # ______
- [ ] recorded by Historic American Engineering Record # ______

Primary location of additional data:

- [ ] State historic preservation office
- [ ] Other State agency
- [ ] Federal agency
- [ ] Local government
- [x] University
- [x] Other

Specify repository: Philadelphia Historical Commission

10. Geographical Data

Acreage of property 1

UTM References

A Zone ___ Easting ___ Northing ___

B Zone ___ Easting ___ Northing ___

C Zone ___ Easting ___ Northing ___

D Zone ___ Easting ___ Northing ___

[ ] See continuation sheet

Verbal Boundary Description

Beginning at a point 200' from the north side of Spruce Street, extending north 150' to a point on the south side of Smith Walk, then proceeding east 62.5', thence 37.5' in a northeasterly direction to another point, thence east 50' to a walkway, then proceeding south 175' more or less, and then proceeding west 150' to the point of origin on 34th Street.

[x] See continuation sheet

Boundary Justification

The boundary encompasses the Institute of Hygiene building, its additions and the landscaped grounds that immediately surround the site. Boundaries are formed by 34th Street on the west, Smith Walk on the north and paved pathways to the east and south.

[x] See continuation sheet

11. Form Prepared By

name/title Susan Glassman, Julie A. Johnson

organization Wagner Free Institute of Science   date March 5, 1993

street & number 1700 West Montgomery Avenue   telephone (215) 763-6529

city or town Philadelphia   state PA   zip code 19121

Between 1881, when he was elected as Provost, until his retirement in 1894, Pepper engineered a remarkable transformation of the school, expanding its campus and systematically reorganizing the faculties and curricula of the College.[2] Among his many innovations were the founding of the College for Women, establishment of a school of nursing, and development of programs in graduate education. But his greatest efforts were lavished on remaking the University's School of Medicine. As an instructor in the school during the 1870s, Pepper had been instrumental in establishing the University Hospital (now the Hospital of the University of Pennsylvania), the first teaching hospital in the United States. He also served as medical director of the Centennial Exhibition held in Philadelphia in 1876, for which he had erected a model hospital and proposed solutions to problems of hygiene and sanitation plaguing America's overcrowded cities. His dual concern with public health issues and the inadequacies of American medical education were reflected in an address he delivered to his medical students in 1877, "Higher Medical Education, the True Interest of the Public and the Profession". His appointment as Provost in 1881 gave him the opportunity to put these ideas into practice.

By the mid-1880s, Pepper had embarked on an ambitious program of reform. At the core of his plan was the construction of a laboratory of hygiene which was intended to serve as the connecting link between graduate medical education, undergraduate science, and the municipal public health community. The initial conception of the Laboratory proposed establishing a new department of hygiene as part of the Department of Medicine. To carry out the plan, a significant sum of money was needed to construct appropriate facilities and for specialized equipment. Pepper, who was known for his savvy fund-raising ability, appointed the influential physician and author Silas Weir Mitchell (1829-1914) as ambassador to one of Philadelphia's most thoughtful and munificent philanthropists, Henry Charles Lea.

An internationally prominent historian and one of the nation's leading medical publishers, Lea (1825-1909) was in lively contact with the political and scientific figures of England and the continent.[3] But he was also deeply involved with civic life in Philadelphia. A founder of the Citizens' Municipal Reform Association, Lea was a leading force in political reform in the city and the state. At the same time he was also one of Philadelphia's most energetic architectural patrons, building with his brother dozens of commercial buildings and rowhouses as well as civic buildings such as the new wing of the Library Company (1888). Lea's work as a medical publisher brought him in contact with the latest medical theories and advances, and he became intensely interested in modern sanitation and hygiene.[4] Rowhouse developments he erected with his brother included innovative plumbing and ventilation systems and were intended as models of modern hygiene.[5] Thus when Mitchell asked him to support Pepper's new Institute of Hygiene, it was a proposal that united three of Lea's main interests: public health, sanitation and medical education.

Lea now became not only a patron of the project, but an active partner in its development. In 1886 he began what would become a three year negotiation with Pepper and Mitchell as to how the department would be realized. Lea was an extraordinary donor: he routinely gave substantial contributions to Philadelphia hospitals, libraries and museums and, beginning with Pepper's tenure as Provost, became an

important supporter of the University of Pennsylvania. However, Lea's gifts were given quietly and he used them to further his own philanthropic aims which did not always coincide with the primary goals of the recipient. When asked in 1887 to support a new library for the University, Lea declined, writing to Pepper "I will frankly say that I should regret the carrying out of your plans because success would mean indefinite postponement of that which I have so earnestly desired to see -- a great library open to all classes and accessible to the greatest number". [6] In the Institute of Hygiene Lea saw an opportunity to benefit not just the University but to make a substantial contribution for the public good.

In 1889 Lea sent Pepper a formal proposal in which he agreed to build and equip the Institute of Hygiene for the sum of $50,000. As usual he attached several conditions: first that the University raise an endowment sufficient to permanently establish the department; second that the study of hygiene be required of all students in the medical school; third that the length of the medical course be increased from three years to four, in accordance with curricular reforms at Harvard and the soon-to-be-opened Johns Hopkins medical school; fourth that he be allowed to select the site of the new laboratory, overruling Pepper, who had suggested a lot at Woodland and 36th Streets (Lea felt the heavy traffic along the street would cause vibrations that would make delicate balance work difficult and that dust stirred up would impede accurate research, instead he suggest a "retired corner" on 34th Street, the site that was ultimately chosen).[7] Finally, Lea demanded that John Shaw Billings, the nation's leading public health expert and designer of the Johns Hopkins Hospital, be brought to the University to design and run the new institute.

The last stipulation most likely was guided by Lea's cousin, Weir Mitchell. Mitchell had met Billings during the Civil War when Billings was still a young surgeon, and the two maintained a lifelong friendship.[8] Both became nationally known figures in medicine, Mitchell as a pioneering neurologist who developed the famous "rest cure" (pioneering feminist Charlotte Perkins Gilman was one of Mitchell's patients, and wrote about the treatment in her famous short story, "The Yellow Wallpaper") and Billings as a medical bibliographer (he founded the Surgeon General's Library, the pre-eminent collection of medical literature from the United States and around the world), sanitary designer and public health expert. When the Johns Hopkins medical school, which served as the arbiter for exemplary medical education in America, was being planned, Billings was selected to design its Hospital. (This building, one of the few others of Billings which remains standing, is listed as a National Historic Landmark.) When the proposal for the Institute of Hygiene at the University of Pennsylvania was advanced, the highly influential Mitchell, who served as Chairman of the Committee on Hygiene, could recommend no more qualified person to direct it than Billings. Lea and Pepper, also cognizant of Billings' genius and clout, leapt at the opportunity to bring Billings to Penn. Billings arrived in Philadelphia in 1890 to serve as the George S. Pepper Professor of Hygiene, the chair endowed by a gift of $60,000 from George Pepper, the provost's brother. In addition he was to serve as consultant on the design of the laboratory building.

With Billings in place Lea contracted with architects Edward Collins, and his partner Charles Autenrieth, to prepare plans for the building. Lea had a long relationship with the firm; in addition to his

own house at 20th and Walnut Streets, he invariably worked with them on his commercial and rowhouse developments.[9] And, when he erected a new building for the Library Company of Philadelphia in 1888, he gave the commission to their firm. Collins and Autenreith were a particularly apt choice to complete plans for the new Hygiene Laboratory. Collins, born in 1823 in Konigsberg, East Prussia, [10] had studied at the polytechnical college in Karlsruhe, one of Germany's leading schools of architecture, taking courses with prominent German architects Heinrich Hübsch and Friedrich Eisenlohr. He had emigrated to Philadelphia in 1848, in the wake of the revolutions across Europe that year. The city's first university-educated architect, Collins prospered in Philadelphia because of his training and his superb drafting ability.

In 1849 Collins went to work for John McArthur, Jr., who later designed Philadelphia's landmark City Hall; together they designed the Girard House, Philadelphia's great hotel of the era. [11] In 1853 Collins formed a partnership with Charles Autenrieth, another German from the same province, initiating a half century of practice together. Their lucrative practice ranged from villas and churches in Philadelphia to a courthouse in Ohio and the vast Union Station in Pittsburgh. [12] Collins' training in polytechnical school also equipped him to specialize in work for scientific and educational institutions. In 1885 the firm remodeled the Wagner Free Institute of Science, then under the leadership of Joseph Leidy, one of America's foremost scientists and a colleague of William Pepper and S. Weir Mitchell at the University medical school.

The Institute of Hygiene reflects Collin's architectural training. At Karlsruhe all of architectural history was subjected to systematic study, from Greek to Gothic; students were not taught to use one style but instead to study all styles and to derive from them abstract principles which could serve to create a new modern style. [13] This new style would be neither classical nor medieval, but instead a synthesis of them both, showing the result as the unmistakable creation of the present.

For its West Philadelphia campus the University of Pennsylvania, like many American colleges, had embraced English Gothic architecture -- from the polychromed exuberance of College Hall to the more archaeologically correct Collegiate Gothic of its dormitories -- to visually express its origins in the great medieval universities of Britain. These buildings evoked the cloistered nature of scholarship, with their curricula focused on the study of cultures of the past and removed from the problems of contemporary life. Unlike the rest of the Gothic campus of the University, the Institute of Hygiene did not evoke the Middle Ages. Instead Collins sought to convey the modernity of the building type -- a dedicated laboratory, whose design, plan and furnishings were shaped by its function, for which there was no precedent in the vocabulary of the medieval university. For this Collins drew on his training in Karlsruhe, creating a form that expressed the utilitarian nature of this new academic discipline and that self-consciously distinguished it from the symbolism of the Gothic campus. By linking the Institute to factories rather than monasteries, Collins represented its function as a workshop for civic science as well as the service ideal it espoused. The design is an outstanding example of Collins' late work, and it shows with great clarity the characteristic elements of the synthetic style of Karlsruhe, neither classical nor medieval, but somewhere in between. The extremely low pitch of the gable is typically German, linking it to other now vanished

works by Collins such as his German Society Building (1866).

Collins was not relying on forty-year old memories for the German elements of his building. The newest hygiene and chemistry laboratories were German, where research in these vital disciplines began, and here Collins found sources for the Institute of Hygiene. The brick and terra cotta walls, horizontal banding and low roof-lines of the hygiene laboratory at the Berlin municipal hospital was a model. Even more recent and prestigious was the new chemistry laboratory in Zurich, which shared with the Institute the arrangement of low projecting wings around a recessed entrance. These buildings were both published in the report on the 1889 Paris World Exposition where the chemistry laboratory was presented as a new building type, something worthy of international attention. [14] The Institute of Hygiene was part of a great international movement, a revolution in scientific investigation that emphasized research and experimentation, and that demanded a new physical form to house it. Here Collins was in his prime, working according to his flexible architectural theory to create a building that is at once modern, refers to its German origin, and is part of its context, to which Collins linked it by colors and materials, roof heights and by its discrete scale.

When it opened in 1892, the Institute was at the forefront of radically new approaches to public health and medicine. The opening was attended by national figures of science, medicine, and public health, such as Colonel George Waring and Dr. Joseph Leidy. "A New Science for America" trumpeted the headline of the Philadelphia Inquirer and the Boston Medical and Surgical Journal, the precursor to the New England Journal of Medicine, reprinted Billings' speech, along with detailed descriptions and plans of the building.

Billings vision for his Institute was a broad one. It was to be more than just a bacteriological laboratory, but one that was equipped as well to perform chemical testing of air, water, food, ice, sewage, soil, and dyestuffs, and for physics investigations into heating, ventilation, and drainage. The concerns of late-nineteenth century industrial society are strikingly illustrated by the problems it was designed to investigate: heating and ventilating homes, schools, and factories; ensuring a pure water supply in the era before municipal water filtration; disposing of household, human, and industrial wastes; and the use of hazardous substances in the hundreds of factories that clustered on the Philadelphia landscape and employed tens of thousands. In addition the Institute was equipped to trace -- and thus prevent -- the transmission of two of the most virulent diseases of the period: typhoid and tuberculosis, the first water-borne and transmissable through water, ice, sewage, and food, and the second air-borne and therefore potentially present wherever an infected person was found.

In his published address at the opening, Billings noted "As regards the external appearance of the building, opinions will, of course, differ. I will only say that it has been planned from within outward, which is the reason why it looks like a laboratory and not like a castle or cathedral...sky-lines and projects or recesses to obtain shadows have not received much consideration; space, light, and adaptation to the work to be done have been the points insisted on."[15] Its large window openings were designed to let

in a maximum amount of light, which was felt to serve both a prophylactic and illuminatory effect in Billings' time. Small mesh-covered intake vents located under each window brought in fresh air from the outside, while the stale and possibly contaminated laboratory air was vented through the roof using a complex and sophisticated convection system of air circulation powered by steam-driven flues which are, remarkably, still in place.

The interior of the building too was designed and outfitted with specialized experiments in mind. In the chemical laboratory even the radiators which heated the space were part of its experimental design, "each of a different pattern, and so arranged as to permit of the testing of the relative efficiency of each... the drainage of the building is on a double system, and is so arranged as to permit the trial of new forms of traps, sinks, closets, etc. All pipes are freely exposed to view, and the different systems for cold water, steam, drainage, etc., are painted a different color." Near the closing of his address Billings remarked on the contrast between the laboratory building and the University's new library noting "it is fit and proper that it should do so [contrast]. The library represents the garnered experience and wisdom of the past; the laboratory is the workshop of the future. One is fruit, the other seed." [16] In its conception and design the Institute of Hygiene represents this important transformation in science and education: from the transfer of old knowledge to the manufacture of new knowledge. Here the building itself served as part of the scientific apparatus with experimental systems built into its interior plan. These systems all remain in place, thus preserving a unique example of an intact nineteenth century research laboratory.

In the years immediately following its construction the university, under Pepper and his successor Charles Harrison, continued to build laboratories and research facilities. A Chemistry lab was built immediately south of the Institute, the University's School of Dentistry was constructed to the east in 1896, two buildings constructed as orphan asylums in the early 1890s were converted for use as physics labs later in the decade, and a building for the Towne Scientific School was erected by 1903, completing a contiguous precinct for science research, just east of the college buildings. The Laboratory of Hygiene formed the core of this complex around which the University's science precinct was developed. The grouping represents the first expansion of the University's West Philadelphia campus, an expansion that expresses its transformation from college to modern research university, and the grouping, along Locust Street (now called Smith Walk) and 34th Street, comprise the only intact ensemble of nineteenth century buildings in their original setting on the campus. Together they form a uniquely preserved ensemble of late-nineteenth century science buildings, which provide a remarkable document of the form and function of turn of the century scientific investigation.

The Institute of Hygiene is a link in the long-neglected story of the United States' German-American architectural heritage, and of role of the German university system in the United States' educational history. It is extraordinary for the way in which its areas of significance -- its style, its architect and patrons, and its association with fundamental changes in medicine, science, public health and education -- are so intricately entwined. The change to a research-based teaching method in the United States occurred at several institutions in a short period of time. The University of Pennsylvania was at

the forefront of this transformation, and Lea, Billings and Collins gave definitive form to the research laboratory. Laboratories and science buildings, because of rapid changes in technology, have not been preserved and recorded. The Institute of Hygiene and the surrounding complex depict this important historical shift in a way few other surviving laboratory buildings in the nation do.

NOTES

1. The changes in the University curriculum during this important period of its history are discussed in Martin Meyerson and Dilys Winegrad, Gladly Learn and Gladly Teach, Franklin and his Heirs at the University of Pennsylvania, 1740-1976, (Philadelphia, 1978), pp. 101-129. Also see Edward Potts Cheyney, A History of the University of Pennsylvania, 1740-1940, (Philadelphia, 1940).

2. Pepper's contributions to the school are detailed in Meyerson and Winegrad, Gladly Learn and Gladly Teach, op.cit. For a discussion of his broader achievements, see "William Pepper", Dictionary of American Biography, Dumas Malone, ed., (New York, 1934), Volume XIV, pp. 453-456.

3. For a full biography see Edward Sculley Bradley, Henry Charles Lea, A Biography, (Philadelphia, 1931).

4. Lea headed the internationally prominent medical publishing firm of Lea & Febiger from 1851 until 1880, when his son joined the firm. For a history of the firm and of Henry C. Lea's contributions, see [Lea & Febiger], One hundred and Fifty Years of Publishing, 1785-1935, (Philadelphia, 1935), and [Lea & Febiger], 1785-1985, Two Hundred Years of Publishing, (Philadelphia, 1985).

5. See the pamphlet, "Handsome and Well-Built Marble Dwellings", (Philadelphia, 1878); collection of the Historical Society of Pennsylvania.

6. Henry C. Lea to Dr. William Pepper. 27 December 1887, Special Collections, Van Pelt Library, University of Pennsylvania. Lea's correspondence concerning his donations to the University of Pennsylvania and other institutions in the Special Collections of Van Pelt Library document both his practices and concerns as a donor.

7. Henry C. Lea to Dr. William Pepper: 25 October 1889; 29 October 1889; 3 January 1890, Special Collections, Van Pelt Library. University of Pennsylvania.

8. Ernest Earnest, S. Weir Mitchell. Novelist and Physician,(Philadelphia, 1950).

9. Lea's building projects are detailed in the two surviving notebooks of architect Edward Collins, Collins & Autenrieth papers; Manuscript collections, Hugh M. Morris Library, University of Delaware.

10. Collins was not born in Philadelphia, as claimed in previous scholarship, such as "Collins & Autenrieth," in Three Centuries of Philadelphia Art (Philadelphia, 1976). See in particular the student rosters from the Karlsruhe Polytechnial School, Schulerlisten 1844-1847, Generallandesarchiv Karlsruhe, 448/1440. There Collins' birthdate is given as October 9, 1823, and not the 1821 generally given. See Michael J. Lewis, "Collins & Autenrieth," Drawing toward Building: Philadelphia Architectural Graphics, 1732-1986, James F. O'Gorman et al, ed. (Philadelphia, 1986). p. 105. Also see Jane Kulcyski Schweizer, "Collins & Autenrieth: Architects in Victorian Philadelphia," M.A. Thesis, University of Delaware (1981)

11. Building VII, no. 15 (October 8, 1887), p. 117.

12. Michael J. Lewis and Jeffrey A. Cohen, "Union Station," in Drawing Toward Building, pp. 114-116.

13. For this curriculum see Festgabe zum Jubilaum er vierzigjahrigen Regierung seiner koniglichern Hoheit des Grossherzogs Friedrich von Baden (Karlsruhe: Technische Hochschule, 1892).

14. Report of the 1889 World Exhibition in Paris (1889); Collection of the American Philosophical Society.

15. John Shaw Billings, "Original Address. The Objects, Plans, and Needs of the Laboratory of Hygiene." Boston Medical and Surgical Journal, February 27, 1892.

16. John Shaw Billings, "Original Address. The Objects, Plans, and Needs of the Laboratory of Hygiene.", Boston Medical and Surgical Journal, February 27, 1892.

The Institute of Hygiene currently is listed on the National Register of Historic Places as part of the University of Pennsylvania Campus Historic District. Although included in the nomination for the district, information on the building is incomplete and it is incorrectly called the John Harrison Chemistry Laboratory and dated 1886. The current nomination is based on expanded research on the development of the Institute of Hygiene and evaluates its significance in the history of education, medicine, science, and public health rather than assessing it purely in terms of architectural style. This additional research indicates that the individual building possesses national significance beyond its contribution as part of the University historic district.

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DOCUMENTATION

C. Floor Plans

Appended are floor plans of the Institute of Hygiene from 1892, showing the building as originally constructed, and from 1985, showing the 1899 wing and current uses of the interior spaces.

D. Photographs

(Note: Items 1-5 are the same for all photographs.)

1) Institute of Hygiene, University of Pennsylvania
2) Philadelphia, Philadelphia, Pennsylvania
3) Fred Quivik, Photographer
4) 1992
5) 515 S. 45th Street, Philadelphia, PA

6) View of the site, looking southeast from 34th Street
7) Photograph 1

6) 34th Street facade, looking east
7) Photograph 2

6) Detail of main entrance on 34th Street, looking southeast
7) Photograph 3

6) North elevation and view of Smith Walk, looking south
7) Photograph 4

6) North and west elevations, looking southwest
7) Photograph 5

6) West elevation, looking northwest
7) Photograph 6

D. Photographs, continued

6) South wing, looking northeast
7) Photograph 7

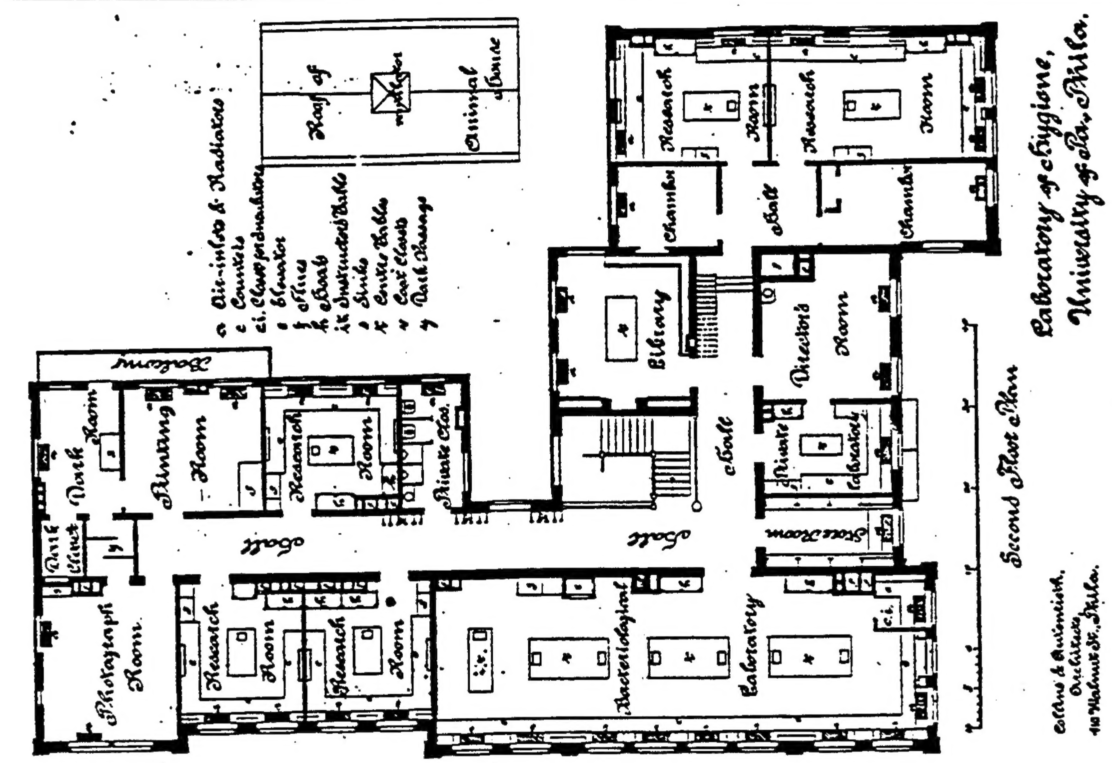
6) View of main facade showing roof, looking east
7) Photograph 8

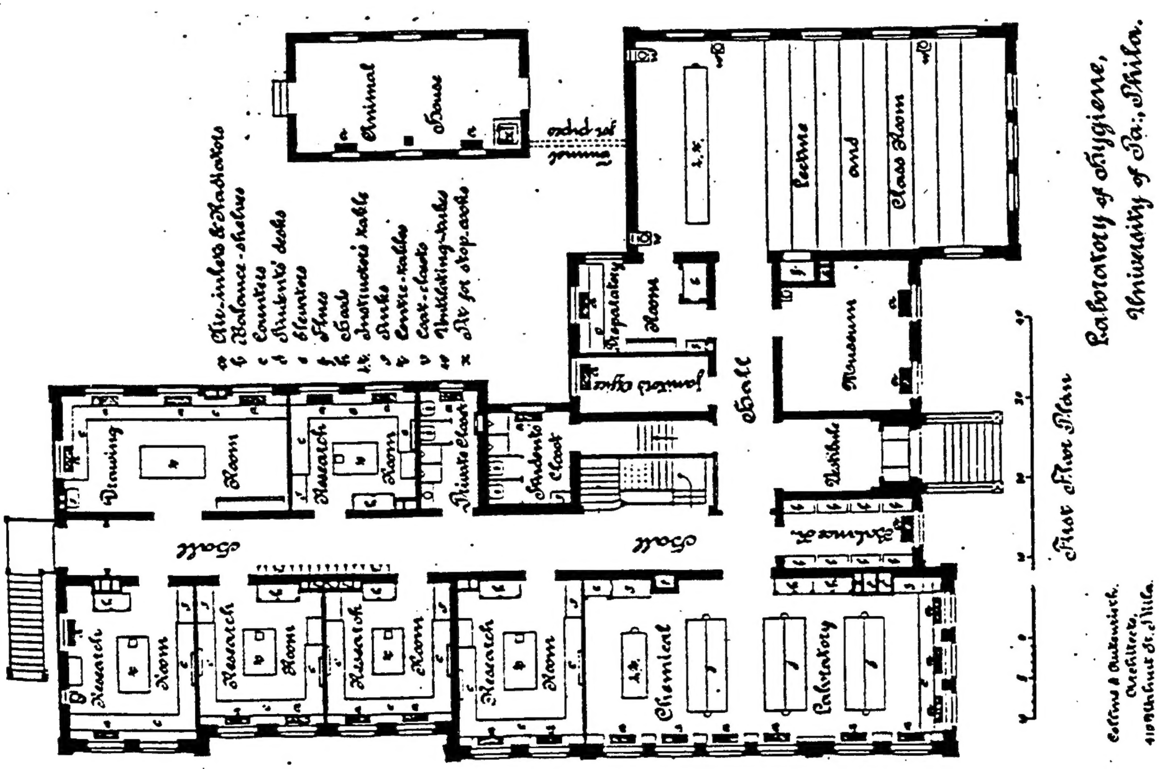
6) Detail of main facade showing trim and vents, looking east
7) Photograph 9

6) Interior view of chemical laboratory in northwest corner of first floor showing experimental radiators, looking northwest
7) Photograph 10

6) Detail of finishes in first floor research room, showing pressed metal ceiling and cornice typical of the interior and out-take vent for laboratory
7) Photograph 11

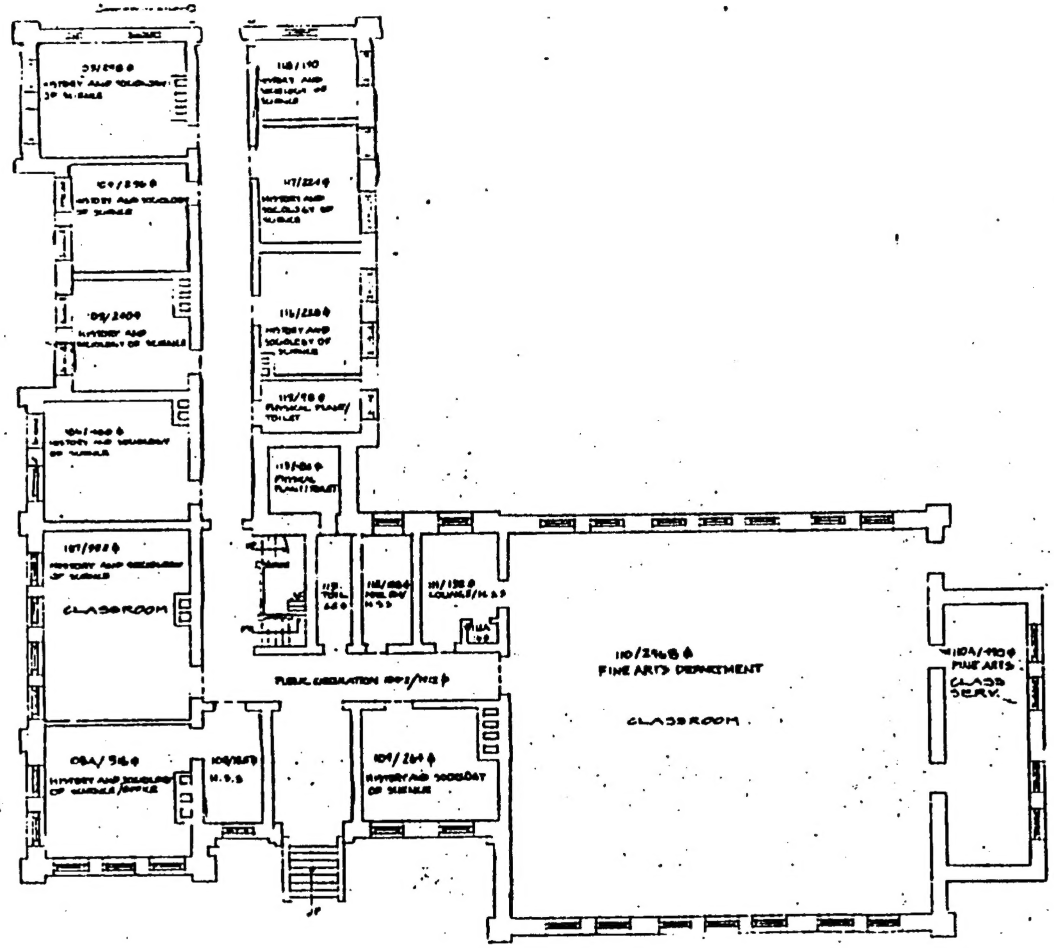
6) Basement detail, showing convection system in place
7) Photograph 12


Second Floor Plan
Laboratory of Hygiene,
University of Pa., Phila.


First Floor Plan
Laboratory of Hygiene,
University of Pa., Phila.

1892

9*

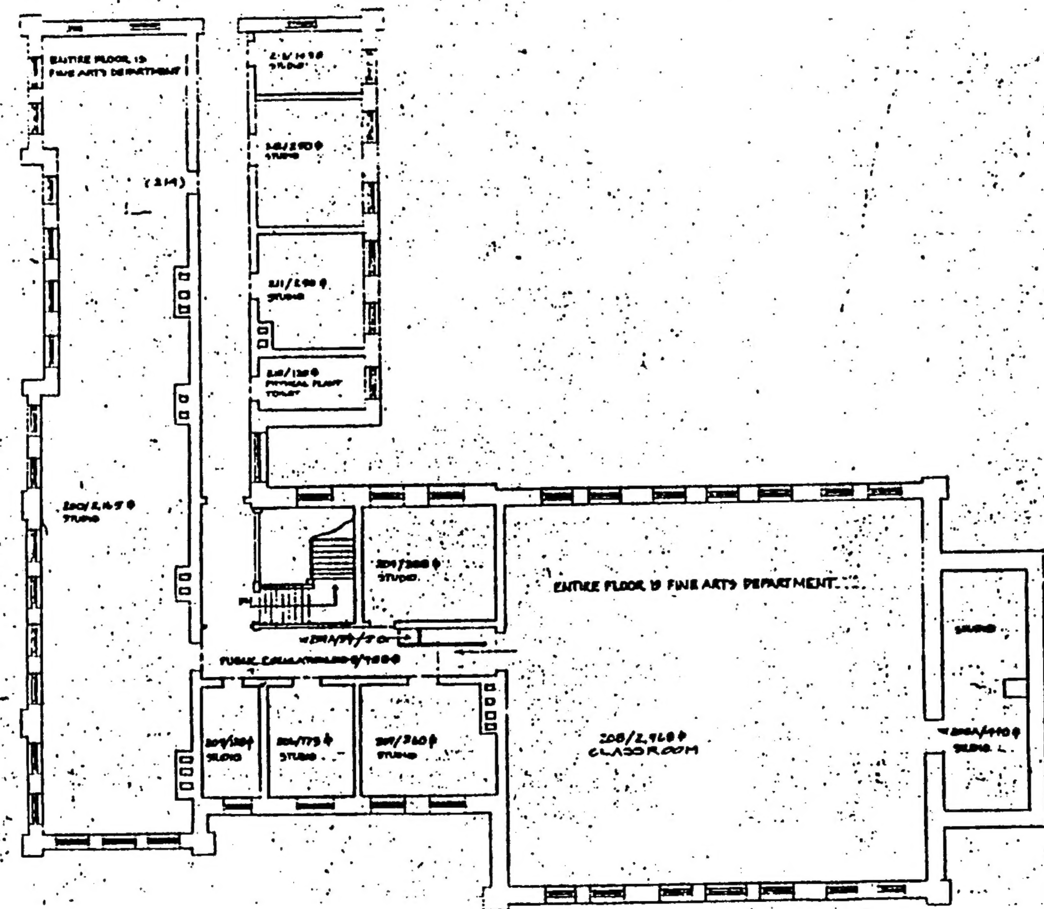


1985

E.F. SMITH HALL

1

1st Floor



1985

2nd Floor

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